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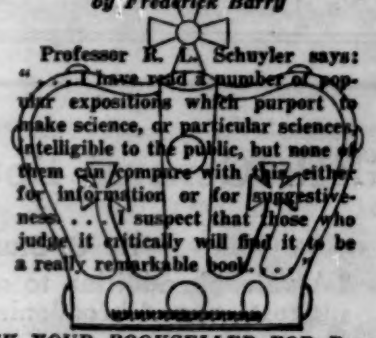

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CONTENTS

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339 East Chicago Avenue
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VOL. LXVIII OCTOBER 12, 1928 No. 1763

CONTENTS

Theodore William Richards: PROFESSOR GREGORY P. BAXTER 333

"Standards" and the Teaching Load in Sciences: M. A. C. 339

The Geographical Distribution of Memberships in the National Academy of Sciences: PRESIDENT W. W. CAMPBELL 342

Scientific Events:
The Centenaries of Thomas Young and Humphry Davy; Old Maps at the British Museum; The Eriksson Prizes; The American School of Prehistoric Research; The Amherst Meeting of the American Astronomical Society; Presentation of a Congressional Medal to Mr. Edison 343

Scientific Notes and News 345

University and Educational Notes 348

Discussion and Correspondence:
A Proposed Change of Electrochemical Nomenclature: MALCOLM DOLE. *An Analytical Directory of Museums:* RALPH C. SMITH. *Occurrence of Germanium in Topaz:* PROFESSOR JACOB PAPISH. *Heterothallism in the Rusts:* PROFESSOR FRANK D. KERN. *The Occurrence of Opistomum pallidium O. Schm. in the United States:* M. E. CARTER. *The Word Caribou:* PROFESSOR L. B. WALTON. *Habit Formation:* PROFESSOR W. A. NOYES 349

Quotations:
Museums and Galleries 353

Scientific Apparatus and Laboratory Methods:
The Micro-abraso-tome: BROOKS F. ELLIS 354

Special Articles:
Series in the Arc Spectrum of Chlorine: DR. T. L. DE BRUIN and DR. C. C. KIESS. *The Relation of Certain Bacteria to the Development of Roots:* PROFESSORS A. J. RIKER, W. M. BANFIELD, W. H. WRIGHT and G. W. KEITT. *The Mechanism of Pellet Formation in the Great Horned Owl:* C. I. REED and BESSIE P. REED 356

Science News x

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal.

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

THEODORE WILLIAM RICHARDS

ON April 2, 1928, the scientific world was shocked by news of the death after a short illness of Theodore William Richards, Erving professor of chemistry in Harvard University. Until within three weeks of his death he performed his usual duties, but from that time he failed rapidly. His father, William Troost Richards, noted marine artist, as well as his mother, Anna Matlock Richards, were natives of Pennsylvania, and it was in Germantown, Pennsylvania, on January 30, 1868, immediately after the return of his parents from a European trip, that Theodore Richards, the fifth child, was born.

Childhood was passed under stimulating surroundings. His father was a very wise and far-seeing man as well as an artist; his Quaker mother an author of both prose and poetry; his three brothers and two sisters as well as he possessed a rich intellectual inheritance; artists, authors and scientists were intimate family friends at his father's Germantown and Newport homes; two years were spent in Europe, largely in England. By a wise decision on the part of his parents, Richards's early education up to the time of entering college was obtained at home from his mother. His quick intelligence was impatient of delay, and to conform to normal educational speed would unquestionably have been irksome if not disastrous. Although he was prepared to enter Haverford College at the age of thirteen and one half, because of his youth entrance to college was postponed for one year. But in the meantime he undertook the studies of the freshman year at home, still under the tutelage of his mother, and joined the sophomore class at Haverford in the fall of 1882.

Scientific interest showed itself early. As a boy he lived through two "boughten" sets of chemicals unharmed, and while still at home was taken into the chemical laboratory of the University of Pennsylvania Medical School by Dr. Marshall and given special instruction in qualitative analysis. In Haverford College, under Professor Lyman B. Hall, he laid a firm foundation for his future work in chemistry, although his interest at that time was divided between chemistry and astronomy. Possibly only the accident of defective eyesight deterred him from selecting the latter field for his life work, but it is probable that acquaintance with Professor Josiah P. Cooke, of Harvard, who was a summer neighbor at Newport, exerted a strong influence on his decision. At any rate,

after graduating with high honors at Haverford in 1885, he entered Harvard College as a senior specializing in chemistry. In order to do this it was necessary for him to pass the examination in Greek for entrance to Harvard. Again, with the help of his mother, he succeeded in preparing for the examination in six weeks of study during the summer. As a senior at Harvard his time was devoted to completing under Professors Cooke, Charles L. Jackson and Henry B. Hill the fundamental preparation necessary for advanced work in chemistry. On commencement, 1886, the bachelor of arts degree was awarded with highest honors in chemistry, *summa cum laude*.

At Harvard the influence of Cooke upon Richards was immediately apparent. Cooke's interests were largely in the field nowadays labeled physical chemistry, partly by inclination, partly perhaps through association with the French physicist Regnault, under whom he had worked some years earlier as a student. One of Cooke's earliest publications concerned the numerical relations between the atomic weights of similar elements. But this investigation had made clear to Cooke the necessity for more accurate determinations of the atomic weights and he had undertaken the experimental revision of some of these constants. Under Cooke, Richards, as a graduate student at Harvard, carried through a redetermination of the relative atomic weights of hydrogen and oxygen, which holds its place to-day as one of the outstanding determinations of this important ratio. No problem of the sort could have presented more difficulties than did this one, and in this investigation appear all the qualities which later were so vital for the work which Richards was to do. An infinite capacity for taking pains, an uncompromising attitude toward the possibilities of hidden errors, a determination to be certain that no precaution had been overlooked, an extraordinary persistence in the patient repetition of exacting and laborious experiments were combined with unusual manual dexterity and ingenuity, the exercise of which must have given great satisfaction to the possessor. One can not but feel that although these qualities would unquestionably have brought success wherever they were directed, chance favored him in presenting at the outset a field in which his talents could be so profitably employed.

After receiving the doctor's degree in 1888 at the age of twenty, Richards spent the following year as the holder of a traveling fellowship in study at German universities under Jannasch, Victor Meyer, Hempel and others. His plan of devoting half of the year abroad to intensive study in one institution, followed by a half year of peripatetic study, was one which he always advocated afterward to students with a similar opportunity, as offering on the whole the greatest good for the time available.

In the fall of 1889 he returned to Harvard as assistant in quantitative analysis, never again to break his connection with the university as a teacher. Promotion to an instructorship came in 1891 and to an assistant professorship in 1894. In 1901 he received the very unusual honor, at that time, of a call to a chair in a European university. The University of Göttingen invited Richards to accept a full professorship in chemistry, with only nominal teaching duties beyond the conducting of investigation. To a man impatient to make rapid progress in research, but working with a heavy teaching load, in a laboratory far from ideal, such an opportunity was tempting in the extreme. Fortunately Harvard appreciated the value of the promising young scientist and rose to the occasion with the offer of a full professorship and an agreement of a drastic reduction in the amount of teaching and administrative duties expected. Upon the retirement of Professor Jackson in 1912, Richards was appointed to the Erving professorship, founded in 1792, the oldest endowed professorship in chemistry in Harvard University.

Immediately after his return from Europe to Harvard in 1889 Richards reentered the field of chemical investigation in which he had already made a beginning, and which was to occupy a large part of his attention during the remainder of his life. Always convinced that only through a precise knowledge of the properties of matter was progress in chemical science to be made, he was fond of making the following quotation from Plato, "If from any art you take away that which concerns weighing, measuring and arithmetic, how little is left of that art!" Furthermore, at that time the atomic weights and the Periodic Law seemed to him to offer more promise of contributing to the understanding of the laws of the universe than any other field of chemistry. In a paper printed in 1910 he says:

> But some may contend that the very exact determination of these quantities is after all an abstract and academic question, not of great practical significance. How will this remote philosophical knowledge yield any practical use? Who can tell? Faraday had no conception of the electric locomotive or the power plants of Niagara when he performed those crucial experiments with magnets and wires that laid the basis for the modern dynamo. When mankind discovers the fundamental laws underlying any set of phenomena, these phenomena come in much larger measure than before under his control and are applicable for his service. Until we understand the laws, all depends upon chance. Hence, merely from the practical point of view of the

progress of humanity, the exact understanding of the laws of nature is one of the most important of all the problems presented to man; and the unknown laws underlying the nature of the elements are obviously among the most fundamental of these laws of nature. In brief, that is the reason why more than twenty years ago the systematic study of the atomic weights was begun at Harvard University by the author.

Observations during the work upon hydrogen under Cooke led him to suspect inaccuracy in the atomic weight of copper and this subject engaged his energies both before and after his trip to Europe. The thoroughness with which this work was done was characteristic. In order to avoid the danger that a single method might be affected by some constant undetected error, not one but several methods were employed, after each method had been scrutinized with the greatest care. The copper was subjected to the most elaborate purification, and in order to make sure that copper always possesses the same atomic weight, no matter where it occurs in the earth's crust, specimens from widely different sources were examined. As a result of this work a new value for the atomic weight of copper was obtained which has shown no evidence of requiring even slight alteration up to the present. The research on copper was followed by similar investigations upon the atomic weights of other common elements, barium, strontium and zinc being those next attacked. Up to the time of his death, either with his own hands or with the aid of assistants, Richards redetermined the atomic weights of twenty-four of the eighty-four elements which have been isolated in quantity.

Greater academic responsibilities, as well as an increasing number of research students, early made it out of the question for him to carry on a large amount of experimental work with his own hands, so that in much of his later investigations the laboratory manipulation was performed by assistants. The necessity for this is obvious if it is remembered that an expert might spend all his time for a year or even several years in the determination of a single atomic weight.

In the course of this work many new analytical processes were devised and old ones perfected. New methods of purification were invented and new criteria of purity established. Especially Richards appreciated the extreme difficulty, not previously recognized, of freeing substances, otherwise pure, from the ever-present water, and devised the well-known "bottling apparatus" for enclosing and preserving the carefully dried substances in a dry atmosphere preparatory to weighing. The "nephelometer" for comparing and measuring traces of solids suspended in liquids was another product of necessity. The importance of taking into account the solubility of "insoluble" substances was pointed out and the great danger of the contamination of precipitates through inclusion and occlusion was emphasized. All these perfections of analytical methods have been of subsequent service not only in the determination of atomic weights but in analytical chemistry in general.

At the outset of Richards's career the work of the Belgian chemist Stas upon atomic weights was universally accepted as representing the nearest approach to perfection which had ever been attained. Constant study of Stas's work enabled Richards to improve upon the former's methods in many ways, without, however, at first arousing any suspicion of inaccuracy in Stas's experiments. For the most part the work of the two had not overlapped, and there had been insufficient basis for comparison. But ultimately discrepancies began to appear, and in 1904 a redetermination of the atomic weights of sodium and chlorine was completed which showed conclusively that in the case of these elements Stas's work was vitiated by appreciable errors not difficult to trace. Subsequent developments in Richards's laboratory have shown that Stas, although years ahead of his time, was in error by important amounts in nearly all his work. A new era in analytical accuracy was thus inaugurated by Richards and the students who worked under him.

Later, in 1913, when the question was raised of probable differences between the atomic weight of common lead and those of isotropes of radioactive origin, it was to Richards's laboratory that Dr. Max Lembert was sent from Karlsruhe with specimens of uranium lead in order to settle this important question. The first direct evidence of the lower atomic weight of uranium lead resulted from their investigation.

Richards is most widely known for his work on atomic weights. It was this work which brought him membership in the American Academy of Arts and Sciences at the age of twenty-three and in the National Academy of Sciences at the age of thirty-one, as well as the Nobel prize at forty-seven. From 1899 to 1902 he was a member of the International Committee on Atomic Weights and since 1919 of the International Committee on Elements and the subcommittee on atomic weights. He never lost interest in this field, and there has seldom been a time when the investigation of one or more atomic weights has not been under way in his laboratory. Furthermore, the experience in exact methods thus obtained was invaluable in the quantitative development of other fields in which he ultimately became interested.

While Richards's original contributions in fields of physical chemistry other than that of atomic weights are too numerous and varied to be described in detail here, certain phases of the work should be emphasized because they represent steps in advance as important from the standpoint of precision as his determinations of atomic weights. His first published paper was concerned with a minor problem in thermochemistry, the constant heat of precipitation of silver chloride. Later, recognizing that this portion of the field of thermodynamics was of fundamental importance, he devoted much time and energy to its practical and theoretical aspects. From a practical point of view he endeavored very successfully to increase the accuracy of thermochemical measurements. This was largely effected by means of the "adiabatic calorimeter" in which the calorimeter is surrounded with a larger vessel, the temperature of which is caused to follow closely that of the calorimeter during the experiment. This ingenious device, original with Richards, although the suggestion had been made earlier by Person, enables the troublesome corrections for loss of heat to or gain of heat from the surroundings and for lag of the thermometer to be avoided. With this apparatus he made accurate measurements of the specific heats of solids at low temperatures, the specific heats of liquids, the heats of evaporation of liquids, the heats of solution of metals in acids, the heats of combustion of organic substances and heats of neutralization.

From a theoretical point of view he early recognized the importance of alteration in the heat capacity of a system undergoing a chemical change, and several years before the publication of the third law of thermodynamics by Nernst, he pointed out the close relation between this alteration and the difference between the "total energy change" and the "free energy change" during a chemical reaction.

Richards was the first to make exact determinations of the transition temperatures of hydrated salts, and to suggest their advantages as fixed points in thermometry, since extreme alterations in the temperature of the thermometer may be avoided by their use.

In electrochemistry Richards made very detailed investigations of the copper and silver coulometers, and showed that Faraday's Law holds with great exactness both in aqueous solution and with fused salts. The study of single potential differences, especially that of iron under varying conditions, and of the electromotive forces between amalgams of different concentrations has engaged his attention at various times.

For more than twenty-five years Richards's activity was very largely concerned with the experimental and theoretical consideration of the apparent volumes and compressibilities of the chemical elements. Experimentally this involved the devising and using of new forms of apparatus for the very exact measurement of the compressibilities of the elements and their compounds, as well as the related properties, surface tension and heat of evaporation. He first developed clearly the close parallelism between atomic volume and compressibility, and the relations between compressibility and increase or decrease in volume during a chemical change on the one hand and chemical affinity and cohesion on the other, and called attention to the extreme improbability of constant atomic volume of an element in different states of chemical combination. In recent years he was engaged in the derivation of a mathematical expression for computing from the compressibilities and other data the actual internal pressures which hold matter together, and had obtained extremely interesting and striking results. The importance of the facts and generalizations in this field brought forward by Richards is beyond question, and while he had made little effort to correlate them with the most recent ideas of the constitution of matter, there seemed to be no conflict in the two points of view.

Besides the foregoing topics many problems in chemical equilibrium and in analytical chemistry are included among the subjects considered in the nearly three hundred scientific papers published during his forty years of activity as an investigator.

While it is always difficult to evaluate the ultimate importance of contemporaneous advances in any field, I believe that every one will agree that Richards's contributions to the technique of precise physicochemical investigation will always stand out prominently in the history of this period of American chemistry. In time further advances will surely come, just as Stas and Richards himself were able to make vast improvements on the existing situations. Doubtless Richards could have carried the refinement of his work to a greater extreme if the needs of the time had required it. Certainly up to the present no one else has done so.

To me one of the most striking features of his work is the uniform care with which every aspect of an investigation was considered and every contingency foreseen. It was never his way to close up the bunghole and leave the spigot open. This was due in part to never losing sight of the fact that measurements, no matter how accurate, are of no permanent value unless the materials being measured are of undoubted purity and definiteness, and the process free from defects, but in part it was undoubtedly due to an excessively cautious temperament, which probably saved him from making false steps. To one familiar

with the experimental methods of his laboratory, it is interesting to see the widespread adoption of these methods by other laboratories in the fields where they are applicable.

It was Richards's belief that his career as a scientific investigator brooked no interference outside the inevitable calls of the university and his home. For this reason he never found time for the writing of books. Aside from several monographs printed by the Carnegie Institution and a collection of papers printed in Germany, his writings were confined to scientific papers, addresses and biographies. For the same reason he was always unwilling to undertake technical or consulting work. And especially during recent years he was seldom seen at scientific meetings because he found the necessary journeys and the attendant excitement too much of a drain on his store of nervous energy.

It was not only as an investigator that Richards's influence was very great. His teaching experience began while he was a graduate student, when he served as a laboratory teaching assistant. In the summer of 1890 he taught elementary chemistry in the Harvard Summer School and devised for the purpose a new inductive method of presenting the subject. This method was later adopted by Harvard University as the approved method of preparing for the entrance examination in chemistry, and exerted a profound influence on the teaching of chemistry in secondary schools, especially in New England. He taught quantitative analysis in Harvard College from 1889 to 1902. In the advanced course the lectures were largely devoted to the application of the most recent advances in physical chemistry to analytical chemistry, an unusual thing at that time. In 1895 the death of Professor Cooke left the course in physical chemistry without a permanent instructor. Richards spent the late spring and summer in Germany studying under Ostwald and Nernst, and in the following year gave for the first time the advanced course in physical chemistry with which he was associated during the remainder of his life. This course dwelt especially with the underlying causes of phenomena without involving the student hopelessly in mathematical details. Since the members of the course were largely graduate students, in order to keep in touch with the undergraduates, Richards gave the whole or a part of a course in elementary physical chemistry presented from an historical standpoint, a side of the subject which he considered of very great importance. Since he possessed to a high degree the faculty of understanding the difficulties of others and of presenting a subject in a simple and illuminating way, these courses were always especially valued by both the students and his colleagues. Fortunate as are those who have had the privilege of hearing his lectures, even more so are those who were his collaborators in research. His daily visits to the laboratories of his research students invariably brought encouragement and inspiration, either through his enthusiasm or by crucial suggestions. Satisfied with nothing but the best, he aroused the students to new levels of carefulness and thoroughness, at the same time insisting on a judicial sense of proportion as to the essential and the non-essential. What wonder therefore that not only American students came to Cambridge for his instruction, but also selected pupils from European institutions, who were sent to his laboratory for special training in exact measurements, a reversal of the old order! Of these, Gilbert N. Lewis in America and Otto Hönigschmid in Germany are best known. In 1907 he spent the second half year at the University of Berlin as exchange professor, the only instruction which he ever gave away from Cambridge.

Although theoretically exempt from administrative duties after his call to Göttingen, in time of need he did not hesitate to step into the breach as Chairman of the Divison of Chemistry from 1903 to 1911, and in this capacity served the Division with the most conscientious attention to detail and with far vision for the future.

All of Richards's early experimental work was performed under most trying conditions in an old and inadequate structure. At no time could he feel sure that noxious gases produced in some remote part of the building would not find their way into his laboratory to ruin the products of days or weeks of labor. On one occasion the ceiling of his laboratory was brought down about his ears by a miniature flood in the room overhead. At this period constant watchfulness to avoid untoward accidents of this sort was as important for his work as analytical skill. That he was able to carry on his work at all under these conditions is a splendid example of the superiority of man over circumstances. Visions of a new laboratory, with freedom from dirt and fumes as well as vibrations, were in his mind almost from the outset. At times the fulfilment of his hopes seemed so imminent that he prepared detailed plans for a research laboratory for exact work, only to be met with disappointment. It was not until 1912 that he was enabled to realize his ambitions in this direction. Largely through the generosity and interest of Dr. Morris Loeb, funds for a research laboratory of physical chemistry were secured. Richards immediately set about the perfecting of the designs of an ideal laboratory with the same care, thoroughness and imagination with which he undertook a scientific investigation. In equipment, convenience, freedom from fumes and dirt, and from rapid temperature

changes the Wolcott Gibbs Memorial Laboratory has probably never been equalled.

The list of honors which he received was a most imposing one. Between 1905 and 1923 he was the recipient of honorary degrees of D.Sc. from Yale, Harvard, Cambridge (England), Oxford, Manchester and Princeton; of LL.D. from Haverford, Pittsburgh and Pennsylvania; of Ph.D. from Prague and Christiania; of Chem.D. from Clark, and even of M.D. from Berlin. The Davy Medal of the Royal Society (London) was received in 1910. On the occasion of the award to him of the Faraday Medal of the Chemical Society (London) in 1911 he delivered an address on "The Fundamental Properties of the Elements." In 1912 the award of the Gibbs Medal of the Chicago section of the American Chemical Society was the occasion of an address on "Atomic Weights." The Franklin Medal was given to him by the Franklin Institute in 1916. The second American scientist and the only American chemist to receive the Nobel Prize, that of 1914 awarded in 1915, he was deterred by war conditions from visiting Sweden at that time, and when later, in 1922, he went to Europe with the intention of delivering the Nobel address, the critical illness of his older son, who accompanied him, again interfered with his visit to Scandinavia. At this time he was given the LeBlanc and Lavoisier Medals of the French Chemical Society. In 1925 he was made an officer of the French Legion of Honor.

Besides holding membership in various American scientific societies he was a vice-president of the Eighth International Congress of Applied Chemistry in 1912, President of the American Chemical Society in 1914, of the American Association for the Advancement of Science in 1917, of the American Academy of Arts and Sciences in 1919–1921, and was to serve as the Honorary Chairman of the September, 1928, meeting of the American Chemical Society. Honorary memberships in the Royal Institution of Great Britain, the Chemists' Club of New York, the Harvey Society, the Franklin Institute, the Royal Irish Society, the Royal Society of Edinburgh, and the French Chemical Society were received in that order. He was Foreign Member of the Swedish Academy of Sciences, the Royal Italian Academy (dei Lincei), the Royal Society of London and the Danish Royal Academy, and Corresponding Member of the Prussian Academy of Sciences, the Brooklyn Institute of Arts and Sciences, the Royal Academy of Sciences of Bologna and the French Academy of Sciences. In 1908 he was appointed Lecturer in the Lowell Institute in Boston and gave a series of lectures on the "Atomic Theory." He was a member of the National Research Council from the time of its organization throughout the war, and during the war was Consulting Chemist under the War Department. Since 1902 he had been a Research Associate of the Carnegie Institution.

It is seldom that an endowed professorship is named for a person then living, but in 1925 Richards's friends were delighted by the announcement that Mr. Thomas W. Lamont, in memory of his brother, Hammond Lamont, had established at Harvard, the Theodore William Richards professorship of chemistry.

Genial and social in his inclinations and with a whimsical sense of humor, he was a welcome addition to any gathering, for his interests included practically every form of human activity, especially art and music. His artistic inheritance might well have been developed as his vocation. As a youngster he planned to follow in his father's footsteps, and always obtained enjoyment from exercising his ability to sketch and paint. One of the most interesting sights in the Gibbs Laboratory was a marine picture which was the joint production of father and son. He was particularly warm-hearted and generous towards his friends. No trouble was too great for him to take in their interests, and no pleasure greater than his at their success. To me the thirty-five years of close association with Richards as his pupil, colleague and friend will always be one of the greatest privileges of my life.

Although never an athlete in a strict sense, he was fond of various outdoor sports. He was especially interested in yachting, and for many years as a young man spent a portion of his summers on his cruising yawl. At one time he was a good tennis player, and he was one of the earlier devotees of golf in America. The latter pastime he never gave up.

In 1896 Richards was married to Miss Miriam Stuart Thayer, daughter of Professor Joseph Henry Thayer, of the Harvard Divinity School. Of their three children, Grace Thayer is the wife of Professor James B. Conant, of Harvard; William Theodore has inherited his father's scientific tastes and is Assistant Professor of chemistry at Princeton University, while Greenough Thayer is a student of architecture.

His domestic inclinations were very strong and his wife's appreciation of his work was extraordinarily sympathetic. It would be hard to decide which was the greatest, his devotion to his family, to Harvard University, or to science, but it is certain that no one could have been more forgetful of self in the interest of any of them. His creed with relation to the last one of the three has been left in his own words, and is typical of his desire to give faithful service;

"First and foremost I should emphasize the overwhelming importance of perfect sincerity and truth;

one must purge oneself of the very human tendency to look only at the favorable aspects of his work, and be ever on the lookout for self deception (which may be quite unintentional). Next, one should never be content with a conventional experimental method or scientific point of view;—one should be open-minded as to the possibility that the procedure or hypothesis may be incomplete. Each step would be questioned, and each possibility of improvement realized. And then, patience, patience! Only by unremitting, persistent labour can a lasting outcome be reached."

GREGORY P. BAXTER

"STANDARDS" AND THE TEACHING LOAD IN SCIENCES

AMONG the "standards" for our colleges and schools formulated by various standardizing and accrediting agencies is usually to be found one that sets a maximum load for teachers. The unit in which the maximum is expressed is the lecture or recitation period. No standardizing agencies attempt in their formulation of standards to differentiate among the various subjects in estimating the teaching load, but some recognize the appropriateness of such differentiation in the administration of their provisions. A number do, however, attempt in their formulated standards to evaluate laboratory work, teaching of other types or auxiliary teaching services in terms of lecture or recitation periods. The evaluation of laboratory work is of peculiar interest to the scientist. It is the purpose of this paper to call the attention of scientists and educators to the fact that the evaluation of laboratory work when embodied in formal "standards" and in practice under less specific provisions is frequently unfair to the teacher of sciences and constitutes in certain cases a serious obstacle to effective teaching.

It is, of course, recognized that many colleges and schools have their own ideals, their own standards for teaching loads, and their own practices in weighing laboratory work in comparison with other types of instruction. So long as these ideals are not lower, the teaching loads not greater and the practices not less liberal than those approved by the standardizing agencies they may be little affected by the agency standards. But many institutions depend upon these agencies to fix their ideals. Some, at least, consider the teaching load set as the maximum by the standardizing agency to be the normal load for their teachers. It is, consequently, of importance that the standards be arrived at with due regard to facts and that they be administered in the light of actual conditions.

Not long ago a man who holds a professorship in a non-science department of a college was comparing the amount of work required of a student in his own courses with that in courses given in other departments. He inquired as to the number of pages in the text used in a particular course in a science and received in reply indication of what to him, manifestly, appeared a very small number. He completed, as he thought, the demolition of his opponent's position with, "And a lot of these pages are taken up with pictures, aren't they?" It is to be feared that many persons, even in educational work, regard the pictures in our texts as so much "filling," expensive filling, necessitated by the styles set by our publishers but justifying slight attention on the part of the student. It is to be feared that many persons regard laboratory work in much the same light—as merely an expensive, fashionable adjunct to the real work of teaching, not making any great demands on teacher or pupil. Indeed, some may be found maintaining that the laboratory is the recreation ground of the teacher of science and that, far from being paid for services there, he might reasonably be required himself to pay a fee, in lieu, for instance, of dues in the country club. It is true that many scientists, by their devotion to the work in their laboratories, lend a certain apparent justification to this view, but it is fundamentally unsound.

The time and energy required by laboratory work varies with the subject, the size of the class and various other conditions, as is true of other types of instruction. In general it may be said that proper conducting of laboratory work involves, while it is in progress, an expenditure of energy on the part of the instructor at least equivalent to that of conducting a classroom recitation. There is the same necessity for quickly sensing the point of view of student after student and for taking measures for eliciting appropriate reactions. But in the typical recitation the attention of the attentive pupils is centered on a common point of discussion. In the laboratory, on the other hand, each properly attentive student is engaged on his separate study; and the instructor, as he turns from one student to another, must constantly shift his attention from one subjective situation to another, from one experiment, one sample of material, one type of difficulty, to another. Furthermore, laboratory work in schools and the great bulk of collegiate laboratory teaching is elementary in character and involves varied materials and methods, for which a maximum of promptly available information and of skill and energy in teaching is demanded. Outside of the periods of actual conduct of laboratory work, there is involved on the part of the teacher a large

amount of work in planning and in providing essential directions, materials and equipment. Whereas in the larger institutions provision of equipment and materials may be the function of persons specifically employed for such duties, in the smaller institutions the instructor is usually obliged to order, or to collect, and to prepare the materials, to assemble and repair the apparatus and to dispose of these after use. Upon first conducting a laboratory exercise or a laboratory course each hour of actual teaching surely requires as much preparation as an hour devoted to delivery of lectures or conducting of recitations would require. After a lecture has been given, its revision and refreshment *may*, under stress of circumstances, be slighted; but preparation for current laboratory work *must* be made. The laboratory teacher, like his comrade in non-laboratory fields, has papers to correct and grading of students to care for. It may be admitted that laboratory work is not in every course, as concerns its contribution to the teacher's load, equivalent hour for hour with lectures or recitations in every course; but any general assumption that the burden of laboratory teaching is less hour for hour than the burden of teaching of other types is utterly wrong. The knowledge that half pay is given by an institution for such work does not encourage the teacher to give his best to it; nor is it conducive in general to that respect which laboratory work should merit and receive. Laboratory teaching, like teaching of other types, is valuable to the pupil and worth while to the institution in proportion to the character and amount of the teacher's preparation for it, the spirit in which he approaches it and the energy he puts into it. Every encouragement should be given him to make the most of his laboratory opportunities.

In view of these considerations attention may well be given to standards formulated by representative standardizing agencies.[1] In the statement that follows, types of formulation of the relevant standards are mentioned and some indications relative to current administrative practice of a few of the numerous responsible agencies are given. No attempt is made to ascribe credit to the originator of a standard for either its substance or its phraseology.

The American Council on Education has taken the lead in an effort to bring about adoption of common statements of standards for educational institutions of various types. For its standards existing statements have commonly been selected and these have been widely copied with more or less modification. These formulated standards recognize the importance of limiting collegiate teaching schedules and make no distinction between teaching of different types in calculating the teaching load. It is highly desirable that agencies whose principles are lower or in whose administration unwarranted distinctions are made should follow this enlightened leadership in expression of principles and should allow no loopholes of interpretation to justify practices prejudicial to the adequate teaching of sciences.

The oldest of our regional associations, the New England Association of Colleges and Secondary Schools, publishes no standards for either schools or colleges. In 1923 the association adopted "Minimum Requirements for an Acceptable College of Liberal Arts," which may fairly be taken as representing its position. The requirement of interest here is as follows: "The college should arrange the teaching schedules so that the total number of hours of any instructor shall vary according to the subject taught, not exceeding eighteen hours per week, including extension work and work in other institutions." No statement as to the practice followed in evaluating laboratory work under this requirement is available.

The Association of Colleges and Preparatory Schools of the Middle States and Maryland, also, has published no policy regarding the weight given to hours of laboratory work in reckoning the teaching load of members of college faculties. In practice, their classification committee has, within ill-defined limits, accepted two hours of collegiate laboratory work as equivalent to one hour of lecture. Standard 5 for secondary schools of the Middle States and Maryland Association, however, specifically permits reduced weight for laboratory teaching. It states:

> The number of daily periods of classroom instruction for a teacher should not exceed five. . . . In interpreting this standard, a double period of laboratory work or of study-room supervision may be counted as the equivalent of one period of teaching.

(Passing over, as merely incidental to the attempt at conciseness of statement, the contrast between laboratory work and teaching, here implied, it may be remarked that study-room supervision may involve more than merely the presence of a teacher to insure conditions conducive to study on the part of pupils. Much attention may be given to individual needs and difficulties. Such work is a strenuous and exacting type of teaching fully equal to a recitation in its drain upon the teacher. So it is in the laboratory,

[1] Names of the various standardizing agencies—national, regional, state and denominational—and much data bearing on their standards may be found in U. S. Bureau of Education Bulletin (1926), No. 10, "Accredited Higher Institutions," or a subsequent edition of this bulletin. Names and addresses of the officers of various agencies may be found in the educational directory published by the same bureau.

except that no one recognizes the purely disciplinary function as appropriate in conduct of laboratory work.)

The standard of the Association of Colleges and Secondary Schools of the Southern States dealing with this matter in colleges of arts and sciences is as follows:

Standard Number 7. Number of Classroom Hours for Teachers. Teaching schedules exceeding sixteen hours per week per instructor shall be interpreted as endangering educational efficiency. In general, two laboratory hours will be counted as equivalent to one recitation hour.

The relevant portion of the standard referring to secondary schools is as follows:

Article 4. (c) The maximum teaching load of any teacher shall be 750 pupil-periods per week with not more than six daily recitations. The commission will scrutinize with extreme care any school in which instructors teach as many as six daily periods. In interpreting this standard, a double period of laboratory, shop, or two periods of study-room supervision shall be counted as the equivalent of one recitation period.

The standards for secondary schools prescribed by the North Central Association of Colleges and Secondary Schools make no mention of any special treatment of laboratory work in reckoning the teaching load. This association's standard for colleges is as follows:

Standard 6. Faculty-Service. The number of teaching hours of classroom work given by each teacher will vary in different departments. To determine this, the amount of preparation required for the class and the amount of time needed for study to keep abreast of the subject, must be taken into account. Teaching schedules exceeding sixteen recitation hours or their equivalent per week, per instructor, will be interpreted as endangering educational efficiency. Institutions which have teachers whose schedules exceed this number must report the facts annually to the Secretary of the Commission on Institutions of Higher Education.

In interpreting the phrase "or their equivalent," the commission exercises special care to see that equivalents claimed as justifying increased teaching hours are really equivalent. Such a provision properly recognizes the necessity for adjustments on the basis of requirements of different subjects and places upon the institution which may advocate reckoning its laboratory work at a lower rate than lecture or recitation work the responsibility for justifying its stand.

The Northwest Association of Secondary and Higher Schools makes no reference in its standards to weighting of laboratory work, but, in practice, it counts two laboratory hours as equivalent to one class period.

The Catholic Education Association, through its commission on standardization of the department of colleges and secondary schools, accredits colleges only. It sets the usual limit of sixteen hours per week for the teacher's load. Inspectors representing the commission are instructed to reckon one and one half hours of laboratory work as the equivalent of one hour of lecture in estimating the load of the teacher.

Other agencies of classes mentioned, a number of the large universities and most of the state departments of education recognize standards identical in phraseology or in effect with one or another of those mentioned above. The need for keeping the teaching load down to a reasonable point in order to make possible the maintenance of a high standard of scholarship in the teacher and a high grade of performance in his teaching is generally recognized. But, in the formulated standards and current practice of many of these agencies, laboratory teaching is improperly represented as of less value than other modes of instruction. Surely upon none is there greater demand than upon the science teacher if he is to keep abreast of his field, aware of its relations to other fields and in touch with current advances in educational thought and practice and with current improvements in the methods of presentation of his subject. Fascinating opportunities for important contributions to educational procedure await his attention. Even more than in most subjects is it both practical and imperative that the teacher of sciences contribute something to the body of knowledge in his field. Not only for the sake of the contribution itself and for his own development, but for the sake of his pupils these research activities are of importance. No presentation of science can be truly effective without emphasis upon the way in which scientific knowledge is won and no other manner of emphasizing this phase can be so effective as to see the truth appearing as a result of persistent research. Nothing adds such zest to the search as the knowledge that this truth is new truth or a new aspect of truth that the mind of man has not compassed before. Discrimination against the teacher of a science through under-valuation of his services in the laboratory is unjust to the teacher, unfair to his pupils and unfavorable to that development in teaching of sciences which the times demand. It is time that scientists should bring this situation to the attention of standardizing agencies and of school and college authorities in positive fashion and should exercise their influence in such ways as may be necessary to remove the handicap under which no small portion of their number are laboring.

It is suggested that those who are concerned investigate the regulations and practices of the organizations which affect them; report pertinent facts through the scientific periodicals; and, through personal influence and the action of groups of scientific men, induce the standardizing agencies to change the discriminatory standards and practices.

M. A. C.

THE GEOGRAPHICAL DISTRIBUTION OF MEMBERSHIPS IN THE NATIONAL ACADEMY OF SCIENCES

THE geographical distribution of memberships in the National Academy of Sciences is a subject of considerable interest, inasmuch as the memberships may be said to have a relationship to research activities in the physical and biological sciences, including anthropology and psychology. The following assignments of residence are as of date August 1, 1928:

MEMBERSHIPS IN STATES		
New York	47	
Massachusetts	40	
California	36	
Illinois	22	
District of Columbia	21	
Connecticut	17	
Maryland	14	
New Jersey	11[1]	
Wisconsin	9	
Michigan	5	
Pennsylvania	5	
Rhode Island	3	
Missouri	2	
Ohio	2	
Arizona	1	
Colorado	1	(retired)
Iowa	1	
North Carolina	1	
Total	238	

The column in the following table headed *M* contains the numbers of academy members who are professors in the medical schools of their respective universities. In several cases it is uncertain whether professors serving their universities in both the medical schools and the academic colleges thereof should be accredited to the medical schools or to the colleges. Another compiler of the table would quite likely make assignments to column *M* differing a little from mine.

The miscellaneous memberships refer to members who are connected with industrial corporations, or are in private practice as engineers, or are serving in other individual capacities. It has not seemed practicable to accredit them to their respective organizations, because of the variety of conditions represented —employee, employer, and so on. However, it is of profound significance that five academy members are research officers in one great manufacturing corpora-

[1] Including one member temporarily residing in Europe.

MEMBERSHIPS IN UNIVERSITIES AND COLLEGES	M
Harvard University	28+7
University of Chicago	13+3
Yale University	15+1
University of California	13+1
Columbia University	13[2]
Johns Hopkins University	4+9
Princeton University	9
Stanford University	9
Cornell University	5+3
University of Wisconsin	8
California Institute of Technology	6
University of Illinois	5
University of Michigan	3+1
University of Pennsylvania	2+2
Brown University	2
Massachusetts Institute of Technology	2
Washington University	0+2
Case School of Applied Science	1
Clark University	1
University of Iowa	1
University of North Carolina	1
Northwestern University	1
University of Pittsburgh	1
Vassar College	1

MEMBERSHIPS IN RESEARCH AND SERVICE INSTITUTIONS	
Carnegie Institution of Washington (including Station for Experimental Evolution, Geophysical Laboratory, Mount Wilson Observatory, and Nutrition Laboratory)	12
Rockefeller Institute for Medical Research	8
Smithsonian Institution (including Bureau of Ethnology and National Museum)	7
U. S. Geological Survey	4
American Museum of Natural History	3[2]
U. S. Bureau of Standards	2
New York Botanical Gardens	2
U. S. Department of Agriculture	1
U. S. Army	1
U. S. Coast and Geodetic Survey	1
Lowell Observatory	1
U. S. Navy	1
Rockefeller Foundation	1
N. Y. State Museum	1
Boyce Thompson Institute for Plant Research	1
Miscellaneous memberships	21

[2] Including two academy members who are assigned to both Columbia University and the American Museum of Natural History.

tion, that two academy members are high officers in a great public-service corporation, etc.

If on the map of the United States a line be drawn, starting on the Atlantic coast at Lynn, Massachusetts, with straight sections of the line terminating successively at Schenectady, New York; Ithaca, New York; Pittsburgh, Pennsylvania; Washington, D. C., and the Atlantic coast, the area limited by this line and the coast line will contain the residences of 158 of the 238 members of the academy, or 66 per cent.

A similar line, starting at Cleveland, Ohio, and passing successively through Detroit, Michigan; Madison, Wisconsin; St. Louis, Missouri, and back to Cleveland, will bound an area in which reside 40 members of the academy, or nearly 17 per cent.

In the State of California, at Berkeley, Palo Alto (Stanford), Mount Hamilton, Pasadena and La Jolla, there reside 36 members, or 15 per cent. of the total membership.

In the western two thirds of the United States, that is, west of a north and south line passing through St. Louis, but excluding California, there are three members: one at Iowa City, Iowa; one at Denver, Colorado (retired), and one at Flagstaff, Arizona.

East of a north and south line drawn through St. Louis, and south of a line starting at St. Louis and running through Cleveland, Pittsburgh, Washington and on to the Atlantic coast, one academy member resides—at Chapel Hill, North Carolina.

The three northern states of New England contain no academy members.

The distribution of memberships in the academy seems to deserve the thoughtful consideration of all those who are in any way responsible for the higher educational interests of the nation.

W. W. CAMPBELL

BERKELEY, CALIFORNIA,
AUGUST 10, 1928

SCIENTIFIC EVENTS

THE CENTENARIES OF THOMAS YOUNG AND HUMPHRY DAVY[1]

Two of the centenaries of greatest scientific interest which occur next year will be those of the deaths of Thomas Young and Sir Humphry Davy, both of whom died in May, 1829, the former in London and the latter at Geneva. The birth of Young took place in 1773, that of Davy in 1778, the centenaries of which, in 1873 and 1878, however, the scientific world allowed to pass without proper recognition. In the case of Davy we commented in our columns at the time on this lack of recognition, adding, "We leave it to a foreign nation to honor the memory of one of our greatest explorers and to a petty provincial town to commemorate the birth of one of our greatest chemists." It is with interest, therefore, we learn that inquiries are already being made as to what steps are being taken to pay due homage to Young, who was the first to explain the phenomenon of the interference of light, who described the optometer, the precursor of the ophthalmoscope, who first gave the word "energy" its present scientific significance, who provided engineers with "Young's modulus," and who deciphered the Rosetta Stone. Of Davy it is only necessary now to recall his experiments with nitrous oxide, his isolation of potassium and sodium, his determination of the elementary character of chlorine and his invention of the safety lamp.

Both Young and Davy came from the "West Country,"—the former from Somerset, the latter from Cornwall—both became distinguished fellows of the Royal Society, both were connected with the Royal Institution, both were foreign associates of the Paris Academy of Sciences, and both are commemorated in Westminster Abbey. If Young surpassed Davy in the depth and range of his scientific inquiries and his immense learning, Davy by his manipulative skill, his command of language and his poetic imagination secured a popularity denied his great contemporary. Both, however, had a world-wide reputation, and while Davy's work is commemorated by the Davy Medal of the Royal Society, Young's is recognized by "The Thomas Young Oration" of the Optical Society. It is to those societies that the scientific world will look for the initiation of the proper celebration of the centenaries of these eminent men of science.

[1] From *Nature*.

OLD MAPS AT THE BRITISH MUSEUM

The Geographical Journal, published by the Royal Geographical Society, London, reports that, on the occasion of the International Geographical Congress, Mr. F. P. Sprent, in charge of the map department, arranged an exhibition of manuscript and printed maps in the King's Library of the British Museum. Among the maps exhibited were several of the unique or rare possessions of the museum, which have frequently been described, such as the world map of 1506 drawn by Contarini (the first printed map to show any part of America), the manuscript map of Guiana drawn for Sir Walter Raleigh and Hondius's world map showing Drake's route on his circumnavigation, with the accompanying "Corte Beschryvinghe" and portraits of Drake and Cavendish. In selecting and arranging the maps, Mr. Sprent has succeeded in combining comprehensiveness with variety, for all the continents and most countries are represented, and most types of maps. The opening section contains

three maps of the British Isles—the first printed map from the Bologna edition of Ptolemy, the map by George Lily published at Rome in 1546 and Saxton's map of 1579—with several specimens of early county maps by Saxton, Norden and Speed, also Lambarde's "Carde, of the Beacons, in Kent" (1596). Then, in addition to that already mentioned, are two other maps illustrating Drake's career, the early French issue of the map of his circumnavigation, probably published in Amsterdam about 1581, and the map from "Summarie and True Discourse of Sir Francis Drake's West Indian Voyage," 1589.

Another section illustrates the early exploration of North America and the search for the North-West Passage with, among others, Michael Lok's map from Hakluyt's "Discovery of America," 1582, and Frobisher's map of supposed North-West passage of 1578. The road-book section comprises the map of Central Europe showing pilgrim routes across the Alps to Rome printed at Nuremberg in 1492, and entitled "Das ist der Rom Weg," one of the earliest printed maps to show any indication of routes, and several of Cary's publications from the end of the eighteenth century.

The manuscript maps are equally comprehensive: a particularly interesting item is three maps of Great Britain drawn by Matthew Paris, of St. Albans, in the middle of the thirteenth century. These show a fairly correct general topographical knowledge, the two outstanding lapses being the significant distortion which makes the Thames a south-coast tributary and the severance of Scotland from England but for a bridge at Stirling. There is also an indication on one of what is assumed to be a high-road from London and St. Albans to Durham. Two small ecclesiastical world maps are also shown, with the characteristic circular form, Jerusalem at the center, and the east at the top, very similar to the early woodcut map from "Rudimentum Noviciorum," Lubeck, 1475, and a fifteenth-century Greek manuscript of Ptolemy. The portolans exhibited comprise elaborately decorated specimens of the work of Battista Agnese, Fernão Vaz Dourado and Diego Homem, and a portion of the east coast of S. America by John Rotz, or Jehan Roze, of Dieppe, 1542. The last section, city views and plans, contains perhaps some of the less well-known items of the exhibition—Cunningham's Norwich, 1559; Lyne's Cambridge, 1574; Hooker's Exeter, 1587; Norden's Westminster, 1593; Hollar's Oxford, 1643, and Millerd's Bristol, 1671. There are also representations of Jerusalem (from Bernhard von Breydenbach's "Peregrinationes," Mainz, 1486), New York and London, the last including works by Agas, Hollar and Rocque. This exhibition is said to offer an opportunity of becoming familiarized with the main developments of historical cartography.

THE ERIKSSON PRIZES

THE committee on the Eriksson Prizes of the International Conference for Phytopathology and Economic Entomology announces that two prizes are offered for the two best memoirs, giving an account of new and original work on the two following subjects, respectively: (1) Investigations on Rust (Uredineae) Diseases of Cereals (Wheat, Oats, Barley or Rye). (2) Investigations on the rôle played by insects or other invertebrates in the transmission or initiation of Virus Disease in Plants.

The value of each prize will be 1,000 Swedish crowns. Competitors may be of any nationality. Three typewritten copies of each memoir must be submitted. They may be written in any one of the three languages, English, French or German. Memoirs must reach the secretary of the committee, Mr. T. A. C. Schoevers, Wageningen, Holland, on or before May 1, 1930.

The author's name must not appear on the memoir itself, but each memoir must be marked with a pseudonym or a motto and the full name and address of the author must accompany the memoir, being enclosed in a sealed envelope bearing on its outside the same pseudonym or motto as is given on the memoir.

The adjudication of the rust prize will rest with a jury, consisting of Professor Dr. Jacob Eriksson, Professor Dr. E. C. Stakman and Professor M. Et. Foëx. The jury for the virus prize will be announced as soon as possible. The decisions of these juries will be final, and will be announced at the fifth International Botanical Conference, to be held in Cambridge (England), from August 16 to 30, 1930. The copyright of the prize memoirs will become the property of the committee, who will endeavor to secure publication of them in a suitable existing periodical or, failing that, procure publication in some other way. Other memoirs will be returned to their authors.

The committee reserves the right to withhold the prizes should none of the memoirs submitted be deemed of sufficient merit by the respective juries. Further particulars, if required, may be obtained on application to the secretary, at the above-mentioned address.

The International Committee for Phytopathology and Economic Entomology, H. M. Quanjer, Wageningen, is president of the committee. The other members are: O. Appel, Berlin-Dahlem; J. Eriksson, Stockholm; J. C. F. Fryer, Harpenden; L. Garbowski, Bydgoszcz; E. Gram, Lyngby; L. O. Howard, Washington, D. C.; J. Jablonowski, Budapest; E. de Jaczewski, Leningrad; S. Kusano, Tokyo; L. Mangin, Paris; E. Marchal, Gembloux; P. Marchal, Paris; C. Moreira, Rio de Janeiro; G. H. Pethybridge, Harpenden; L. Petri, Rome; T. A. C. Schoevers, Wageningen, and C. L. Shear, Washington, D. C.

THE AMERICAN SCHOOL OF PREHISTORIC RESEARCH

DR. GEORGE GRANT MACCURDY returned to Yale University on October 5 after three months in Europe conducting the eighth summer session of the American School of Prehistoric Research, of which he is director. The season's work was confined to England, France and Spain.

Dr. MacCurdy announces that the school is to carry on field work during the late autumn and spring. This is being done through joint cooperation with two British institutions: (1) the Percy Sladen Fund; and, (2) the British School of Archeology at Jerusalem. The autumn expedition to Iraq is already in the field, the American School's representatives being Robert A. Franks, Jr., and Francis Turville-Petre. The representatives of the Percy Sladen Fund are Miss Dorothy A. E. Garrod and Mrs. Neil Baynes, O. B. E. All four have had experience in field work. Turville-Petre was the discoverer of the Neanderthal skull from Galilee; and it was Miss Garrod who discovered the remains of a Neanderthal child at Gibraltar in 1926. The district to be covered is Sulaimanieh, lying to the northeast of Bagdad.

The second cooperative project will be with the British School of Archeology at Jerusalem, the site being the cave of Shukbah on Mt. Ephraim, some seventeen miles northwest of Jerusalem. Miss Garrod, with the help of two former students of the American School of Prehistoric Research, has already dug one season at Shukbah, which turns out to be a station exceedingly rich in remains of both the Paleolithic and the Mesolithic Period.

Dr. MacCurdy brought back with him two tools of rock crystal that were fashioned by Neanderthal artisans perhaps a hundred thousand years ago, and dug from the "Abri des Merveilles" in the Dordogne by two of the students.

THE AMHERST MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY

ON September 12 the American Astronomical Society, at its annual meeting at Amherst, elected to honorary membership Henri Deslandres, director of the Paris Observatory. The constitution of the society permits only one such election a year and only seven living astronomers have been thus honored. Deslandres has been a pioneer in both stellar and solar spectroscopy. He was the first to see the necessity of controlling the temperature of a stellar spectrograph, and did so by allowing water from the city mains to flow around the instrument. He discovered the binary character of Delta Orionis. He invented simultaneously with Hale, and independently, the spectroheliograph; and shares with Hale the credit for the discovery of solar flocculi. He has also invented another instrument of somewhat similar character, which he has called the "spectrograph enregisteur," by which the radial velocities at all points of the solar surface can be measured. He founded the observatory at Meudon for the investigation of solar physics and has been its only director. In 1926, when B. Baillaud retired as director of the Paris Observatory, Deslandres was chosen to succeed him, and under his direction the two observatories of Paris and Meudon are now combined.

The following officers of the society for the ensuing year were elected:

President: E. W. Brown.
Vice-president: V. M. Slipher.
Secretary: R. S. Dugan.
Treasurer: Benjamin Boss.
Councilors: F. B. Littell, F. E. Ross.
Member Division of Physical Sciences, National Research Council: W. S. Eichelberger.

PRESENTATION OF A CONGRESSIONAL MEDAL TO MR. EDISON

UNDER a resolution of Congress approved May 29, 1928, the Secretary of the Treasury was authorized and directed to cause to be struck and presented to Thomas A. Edison a gold medal. Several designs were submitted to the treasury for consideration. Secretary Mellon has approved the design executed by John R. Sinnock, Philadelphia, Pa., and such approval is concurred in by the Commission of Fine Arts. The medal is now being prepared in the United States Mint at Philadelphia.

Formal presentation of the medal will be made in Mr. Edison's laboratory, West Orange, N. J., on Saturday evening, October 20. Preceding the ceremonies in West Orange a short address will be broadcast by President Coolidge over a nation-wide hookup of radio stations, contributed by the General Electric Company, and the program will then be transferred to the Edison laboratory at West Orange, from which the remainder of the program will be broadcast. Presentation of the medal will be made by Secretary Mellon, and the ceremony in West Orange will also include an address by a person of national prominence. The ceremonies will probably occupy the period of one hour, beginning at 9 P. M., Eastern Standard time.

SCIENTIFIC NOTES AND NEWS

THE Morris Liebmann Memorial Prize of the Institute of Radio Engineers has been awarded to Professor W. G. Cady, head of the department of physics at Wesleyan University, for his investigations in the field of piezo-electric phenomena. The prize will be

presented to Professor Cady at the November meeting in New York.

A ROOSEVELT medal for distinguished service has been awarded to Dr. Frank M. Chapman, of the American Museum of Natural History.

AT the convocation of Queens University, at Kingston, Ontario, the doctorate of laws was conferred on Dr. William H. Nichols, manufacturing chemist, of New York City.

JOHN HAYS HAMMOND has been elected to honorary membership in the American Society of Mechanical Engineers.

VILHJALMUR STEFANSSON has been awarded the Carl Ritter medal of the Geographical Society of Berlin. As Mr. Stefansson was unable to visit Berlin to receive the medal, the presentation was made at the recent meeting of the Congress of Americanists in New York by Professor Albrecht Penck, president of the society.

A subscription dinner will take place on November 10 in honor of Dr. William A. White, on the occasion of the completion of his twenty-fifth year as superintendent of St. Elizabeth's Hospital, Washington, D. C.

DR. T. L. DE BRUIN, professor of physics at the University of Amsterdam, has been appointed a fellow of the International Education Board. He will spend a year at the Bureau of Standards on problems of spectral analysis and atomic structure.

DR. P. LECOMTE DU NOÜY, formerly associate member of the Rockefeller Institute, has been appointed a member of the Pasteur Institute of Paris. He has been put in charge of a new department of biophysics.

DR. W. T. H. WILLIAMSON, senior assistant lecturer in agricultural chemistry at the Edinburgh and East of Scotland College of Agriculture, has been appointed director of the chemical section of the Egyptian Ministry of Agriculture at Cairo, in succession to Mr. W. S. Gray, who died on August 31.

HOWARD R. TOLLEY has been appointed assistant chief in charge of research of the Bureau of Agricultural Economics, Department of Agriculture. Mr. Tolley has been connected with the Department of Agriculture for 13 years.

J. R. VAN PELT, JR., has resigned from the staff of the department of geology in the University of Chicago to become curator in charge of the division of geology, mining and metallurgy in the recently organized Rosenwald Industrial Museum of Chicago. Mr. Van Pelt was formerly professor of geology at Cornell College, Mount Vernon, Iowa, and geologist of the Ranger-Naturalist organization of Yellowstone National Park. He has also been engaged during the past two years in field research in west-central Illinois for the Geological Survey of that state.

DR. GUSTAVUS ELIOT has resigned as dean of the Connecticut College of Pharmacy and has been made dean emeritus. He has served as dean of the college since it was founded four years ago.

BURNETT SMITH, PH.D. (Pennsylvania), has resigned the professorship of paleontology at Syracuse University.

PROFESSOR LAFAYETTE B. MENDEL, Yale University, has been appointed a member of the Committee on Training in the Medical Sciences of the Commission on Medical Education.

PROFESSOR ROBERT MUIR, F.R.S., Sir John Herbert Parsons, F.R.S., and the Right Honorable Sir Charles Philips Trevelyan, M.P., have been appointed members of the British Medical Research Council, filling the vacancies caused by the retirement of Professor Georges Dreyer, Sir Archibald Garrod and the Right Honorable William Graham, M.P. The new appointments became effective on October 1.

DR. GILBERT N. LEWIS, dean of the college of chemistry at the University of California, has returned after attending a congress of physicists in Russia in which twenty-five foreign nations took part.

DR. C. G. ABBOT, secretary of the Smithsonian Institution, returned to Washington on September 23 after an expedition to Mount Wilson, where he made bolometric observations of the infra-red solar spectra and radiometric observations of the spectra of many stars.

DR. L. C. GRAY, in charge of the division of land economics of the bureau of agricultural economics of the U. S. Department of Agriculture, has been selected as the temporary delegate of the United States to the ninth general assembly of the International Institute of Agriculture at Rome. The assembly convenes on October 10 and continues in session for a period of about two weeks. Dr. Gray sailed for Cherbourg on September 19. He and Asher Hobson, permanent delegate of this country to the institute, will probably be the only representatives of the U. S. Government this year, instead of the usual delegation of eight or ten in former years.

DR. A. J. CARLSON, of the University of Chicago, will give the first Harrington lectures at the University of Buffalo on November 15 and 16 on the "Function of the Stomach in Health and Disease."

THE Lane medical lectures, which are to be delivered by Professor Walther Straub, of Munich, at the Stanford University Medical School, San Francisco, have been definitely scheduled for April, 1929. The titles of the lectures are as follows: "The Pharmacology of Heavy Metals," "The Chemistry and Pharmacology of Digitalis and its Derivatives" and "Recent Development in Narcosis."

THE non-resident lecturer in chemistry on the George Fisher Baker Foundation of Cornell University for the first semester of the academic year 1928–1929 is Professor Hans Pringsheim, of the University of Berlin, one of the leading investigators in the field of the sugars. His introductory public lecture given on October 4 was entitled "Twenty-five Years of Biochemistry."

THE Norman Lockyer lecture of the British Science Guild will be given this year by Professor J. Arthur Thomson, Regius professor of natural history, University of Aberdeen, on "The Culture Value of Natural History." The lecture will be delivered on the afternoon of Wednesday, November 28, in the Goldsmiths' Hall, London.

Nature notes that the following foreign men of science were expected as guests of the Faraday Society at the discussion held at Cambridge on September 28 and 29 on "Homogeneous Catalysis": Professor H. Bäckström, Princeton; Professor J. Böeseker, Delft; Dr. E. J. Bigwood, Brussels; Professor J. N. Brönsted, Copenhagen; Professor H. Copaux, Paris (president of the Société de Chimie et Physique); Professor H. Dufraisse, Paris; Professor H. von Euler, Stockholm; Professor F. Giordani, Naples; Professor C. Moureu, Paris; Dr. Henri Moureu, Paris; Professor M. Polanyi, Berlin; Professor F. O. Rice, Johns Hopkins University, U. S. A. Professor J. W. McBain, a vice-president of the Faraday Society, now at Stanford University, California, also attended the meeting.

THE death at the age of sixty-one years of L. W. Dowling, professor of mathematics at the University of Wisconsin, is announced.

ED. H. WEBSTER, chief of the dairy division of the Bureau of Plant Industry, died on August 24 at the age of fifty-seven years.

DR. HOMER E. SMITH, the well-known oculist, died in Norwich, N. Y., on October 5, at the age of seventy-three years.

THE death at the age of forty-six years is announced of Dr. Wilhelm Wien, professor of experimental physics in the University of Munich, known especially for his work on cathode and canal rays.

THE Committee of One Hundred on Scientific Research of the American Association for the Advancement of Science has been authorized to undertake a study of present conditions with reference to influences that may favor or hamper research in this country. Several subcommittees have presented communications based on their work at previous meetings of the association. At New York the subcommittee on the "Economic Status of Scientific Workers" will present a program based on a study of the salary conditions in academic institutions and the ways in which these salaries are expended. Since inadequacy of salaries is often met with, ways in which this deficiency is supplied will be considered. The competition of other lines of employment in the matter of pay will be indicated in a discussion of pay scales of trained men and women in several lines of employment. The work of this committee will be presented at a general session of the association to be held in New York during the holiday week. Prominent educators and students of the problems will present papers and conduct the discussion.

THE Pasteur Society of Central California met at the Hotel Stewart in San Francisco on the evening of September 25. The subjects of the general symposium on the latest developments in milk control were as follows: "Bacteriological Tests and Controls," by Dr. C. S. Mudge, division of dairy industry of the college of agriculture of the University of California, Davis, discussed by Mr. A. M. Besemer, Golden State Products Company, San Francisco; "Undulant Fever from Milk," by Dr. E. C. Dickson, Stanford University Medical School, discussed by Dr. J. Traum, division of veterinary science, University of California; "The Latest Developments in the State Legal Control of Milk," by Dr. C. U. Duckworth, director of the bureau of dairy control of the State Department of Agriculture, Sacramento, discussed by Dr. W. H. Kellogg, director of the bureau of communicable diseases of the State Board of Health. The papers were followed by a general discussion.

THE submarine S-21, tended by Eagle boats 35 and 58, left the Washington Navy Yard on October 2 for its scientific expedition to determine the gravity of the earth undersea and its relation to earthquakes. Preparatory to the taking off, Secretary Curtis D. Wilbur, accompanied by Admiral Charles F. Hughes, chief of naval operations; Rear Admiral R. H. Leigh, chief of the Bureau of Navigation; Elmer B. Collins, of the Hydrographic Office of the Navy, and Dr. Fred E. Wright, of the Carnegie Institution of Washington, inspected the submarine. Professor F. A. Vening Meinesz, inventor of the pendulum apparatus with which the studies will be made, exhibited the device

to the party, and held "open house" to other scientists in the vicinity of Washington. The purpose of Dr. Meinesz' visit is to extend the gravity determination network now covering the land areas of the United States until it shall include the coastal waters of the Atlantic to the east and Gulf of Mexico and Caribbean waters to the south.

ON the afternoon of October 10 the president and trustees of the American Museum of Natural History threw open to view the new Rotifer Group in the Darwin Hall on the first floor of the museum. This group, the specimens for which have been formed in glass, represents a cubic half inch of pond bottom magnified one hundred diameters. It is so constructed as to represent a huge magnifying glass through which the observer gazes into a jungle of water plants peopled by hundreds of tiny animal forms. The group has been modeled in glass by Hermann O. Mueller, of the museum. The coloring of the models and background has been executed by W. H. Southwick. The features of the pond bottom, constructed in wax, were modeled by Chris E. Olsen, and the field sketches from life were prepared by Dr. George H. Child. All of the work was designed and directed by Dr. Roy Waldo Miner, curator of marine life in the museum.

THE University of California Medical School sponsored two public motion picture films at the University Hospital, in San Francisco, on October 8, exhibited by Robert J. Ruth, of E. R. Squibb and Sons. The subjects were "Sunshine from the Sea," which presents the subject of cod-liver oil. The second, "How Science Aids in Controlling Infectious Diseases," will depict methods employed in the manufacture and control of biologic products.

THE Yugoslav government, desiring to make Belgrade a center of Russian science abroad, has opened in Belgrade a "Russian Institute." Its members will be selected from among exiled Russian professors in many countries. The fourth congress of Russian professors abroad opened in Belgrade in September. There were over 150 delegates from various countries. The three former congresses were held in Prague.

THE Chile station of the Lick Observatory, maintained since 1900 in order to observe stars in the southern part of the sky, has been sold, according to a report given out by Science Service, to the Catholic University of Chile. Dr. Robert G. Aitken, associate director in charge of the observatory, explained that the abandonment of the branch observatory, which was equipped with a 37-inch reflecting telescope, did not mean that they had lost interest in the southern hemisphere, but that if adequate support were obtained at some future date another southern station might be established. Probably this would be either in Australia or South Africa. Professor Fred J. Neubauer, who has had charge of the Chile station, will remain there until May 1, 1929, as professor extraordinary in the Catholic University. During this time he will instruct the future workers in the use of the instruments. Following that he will return to Mt. Hamilton. Thousands of photographic plates made in Chile are preserved at Lick Observatory for future study.

THE board of directors of the American Electrochemical Society has established an annual award of one hundred dollars in gold for the best paper printed in the two volumes of any year of the *Transactions* by a student or young graduate under twenty-seven years of age. The judges to pass upon the merits of the manuscript are to be the members of the publication committee, this committee being at liberty to invite the opinion of members not on the committee. The first prize of $100 is to be awarded for the best paper presented at the spring and fall meetings in 1929. This prize is to be known as the American Electrochemical Society prize—to be available at all American or foreign technical schools and colleges, to students and young instructors—the object being "to stimulate original work and encourage participation in the proceedings of the society by scientifically and technically trained men at an age when normally modesty keeps them in the background."

THE following awards for the year 1928–29 are reported in *Nature* to have been made by the Salters' Institute of Industrial Chemistry and approved by the Court of the Company: Fellowships have been renewed to: Mr. C. G. Akhurst (Fellow, 1927–28, at the Rothamsted Experimental Station) for one year at the Imperial College of Tropical Agriculture, Trinidad; Mr. F. Witt (Fellow, 1927–28, at the Gas Institute, Karlsruhe) for one year in a German industrial fuel undertaking. Fellowships have also been awarded to: Mr. H. K. Cameron, University College, London; Mr. H. Diamond, University College, London; Mr. F. L. Gilbert, University College, Nottingham, and Cambridge; Mr. C. H. Lea, University of Liverpool; Mr. A. H. Loveless, of the Imperial College, London; Mr. H. Smith, of the Imperial College, London. Seventy grants-in-aid have also been awarded to young men and women employed in chemical works, to facilitate their further studies.

UNIVERSITY AND EDUCATIONAL NOTES

THE new physics building of the University of Washington, Seattle, erected at a cost of $464,000, will be occupied for the first time this fall. It has

seven small research laboratories, a large general laboratory and several special laboratories, including rooms for music and sound, photography, optics, illumination, electrical measurements and heat and temperature measurements. One room will house a physics library. One of the two large lecture rooms seats two hundred and eighty students and the other eighty. There are twelve smaller recitation rooms.

A NEW chemistry laboratory for Purdue University will be started in the spring. It is planned that when completed this building shall be one of the largest and best-equipped laboratories in the country.

DR. K. LARK-HOROVITZ, of the University of Vienna and more recently of Stanford University, has been appointed professor of physics at Purdue University. He will have supervision of the advanced work in physics and will pay special attention to the development of research.

DR. J. J. WILLAMAN, of the division of agricultural biochemistry, University of Minnesota, has been promoted to a professorship. Mr. Charles F. Rogers, formerly assistant professor of botany of the Colorado Agricultural College, has joined the staff with the rank of instructor.

DR. ANNA R. WHITING has been appointed professor and head of the department of biology at the Pennsylvania College for Women, Pittsburgh, Pa.

DR. FREDERICK E. EMERY, instructor in physiology at the University of Wisconsin, has been appointed associate in physiology at the University of Buffalo.

DR. HELEN BOURQUIN, formerly professor of physiology at the University of South Dakota, has been appointed assistant professor of pharmacology at the University of Michigan.

DISCUSSION AND CORRESPONDENCE

A PROPOSED CHANGE OF ELECTROCHEMICAL NOMENCLATURE

WHEN Faraday[1] in 1833 proposed the new terms *cathode, anode, cation* and *anion,* the nature of electricity and particularly the manner of electrical conduction in solutions were not clearly understood. Since he had no other basis for naming the electrodes, he called that one towards the east the *anode* and that one towards the west the *cathode.*

This nomenclature to-day would appear quite ridiculous if long usage had not accustomed the names to our ears. Indeed, as illuminating and descriptive terms they are useless and a beginner remembers only with difficulty whether the anode is the positive electrode or not. To overcome this difficulty, to place the electrode names on a more logical basis and to simplify electrochemical nomenclature, I should like to propose that the terms anode and cathode be rejected and that in their places an abbreviation of the terms positive electrode and negative electrode, namely, pos-ode or *posode* and neg-ode or *negode,* be substituted. None would have difficulty in telling at once that the posode was the positive electrode and that the negode was the negative electrode.

Furthermore, in 1833 the idea that like and unlike, or positive and negative, attract each other was also not well understood, so Faraday decided to call those bodies which pass to the anode the anions, and those which pass to the cathode the cations. At the present time, however, the fact that positive particles are attracted by the negative electrode is so very well known that Faraday's terminology for the ions is unnecessary. Hence, just as positive electrode was contracted to posode, positive ion can be contracted to pos-ion or *posion,* and, similarly, negative ion can be contracted to neg-ion or *negion.* A glance at either of these two simplified names will enable any one to tell at once which is the positive and which is the negative ion.

A further advantage of this new system of nomenclature is seen in X-ray tube phenomena. The negative "particles" or electrons which stream from the negative electrode are called cathode rays. To one unfamiliar with this terminology the question immediately arises whether cathode rays like cations travel to the cathode or whether cathode rays have the same electrical sign as the cathode. This obvious inconsistency in chemical usage no longer exists if cathode rays are called *negode* rays; then, just as *negions* are negative ions, so *negode* rays must be negative rays.

The only other difficulty in adopting this new system is an etymological one. Unfortunately, positive and negative are not of Greek origin, as are ode and ion, but this trouble is insignificant compared to the advantages to be gained.

MALCOLM DOLE

ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH

[1] *Philosophical Transactions 123,* 48 (1833).

AN ANALYTICAL DIRECTORY OF MUSEUMS

WITH the tremendous growth of museum collections of all kinds within recent years there is a constantly increasing demand for information regarding both museums and their contents. The profession is continually seeking statistics on the administrative and financial phases of its activities, and the general public

is in need of information regarding the location of museum material in order that such material may be more fully utilized. To meet these needs a proposal has been made that some central agency attempt the compilation of what might be called an analytical directory of museums.

Data regarding museums, which would permit of the fullest utilization of the vast stores of material and at the same time assist those engaged in museum work to study the relations of individual institutions to museums as a whole, would need to be national in scope. A mass of material concerning every museum should be brought together and arranged in such a manner that the field could be viewed from a great variety of angles in an expeditious manner. No single museum would be justified in undertaking a work of this sort, yet every institution would doubtless be willing to cooperate. Its publication by a central agency, such as the American Association of Museums, would be feasible, and the demand for such a book promises to be sufficient to warrant the undertaking.

The increase in the number as well as the size of American museums has made a knowledge of their collections far beyond the capacity of even a large group of persons. While a specialist in a single field may be informed regarding the location of all important material appertaining to his branch of science or art, it is often difficult to get into immediate communication with such a person, and many would be required in order to cover the entire field of modern museum effort. The value of summarizing the information possessed by those best qualified to interpret museums becomes apparent when we consider the advantages of using the material not of one museum but perhaps of a dozen or more.

Very few museums have series of objects in any category which are not supplemented and amplified by the possessions of other institutions. The immediate knowledge of the whereabouts of all important accumulations covering a certain subject may be of inestimable value to an investigator. A published survey of the sort suggested would obviate in many cases the necessity for hurried and often cursory inquiries among a few museums selected more or less at random. Advantages would accrue not only to the public but museums would find themselves benefitting from the increased interest in and use of their collections.

When museums as a group have available exact information as to their status with relation to the political divisions of the country, to population and to each other, more efficient administrative methods will be possible and certain duplications of effort will be revealed. Perhaps no greater need for information regarding the distribution, kinds of museums and means of support, is felt than by the organizers of proposed institutions or the directors of small existing museums. With many duties of a highly diversified character often imposed upon a single person in the capacity of director, the need for tabloid information is keenly felt.

These statements recognize briefly the two main divisions of the proposed analytical directory. Elaboration of what might be called the professional aspect would include statistical consideration of museums in relation to population, distribution of the different types of museums, relative attendance, types of administrative control, tables showing increase in the number of museums and sundry other arrangements of facts. In order to supply the kinds of information usually sought by the general public the directory would list museums geographically as well as according to type, there being general descriptions of each organization and its scope. Indexes would furnish a key to the location of all important collections in a large number of fields, descriptions furnishing some indication of the relative importance and extent of each accumulation. Other lists would show the serial publications of museums, staff members, educational and other activities carried on to supplement exhibited material. Further ramifications would suggest themselves as the work progressed and could be incorporated if time and funds permitted.

RALPH CLIFTON SMITH,
Acting Director, The American Association of Museums

OCCURRENCE OF GERMANIUM IN TOPAZ

IT is an established fact that germanium is closely related to tin in a chemical sense. The two elements have analogous compounds and they occur together in natural minerals such as sphalerite and enargite. With this as a basis a search for germanium was undertaken in cassiterite from numerous localities. The arc spectrographic method was employed[1] and it was observed that while germanium was present in practically all the cassiterites examined, it was present in them in bare traces. This low content could be explained by assuming that the original magma carried very little germanium as compared with tin. But since nothing is known of the mineralogical identity of germanium in cassiterite, it was safe to assume that, irrespective of chemical similarity, segregation took place during or before the final formation of the hypothermal veins or pegmatite dike minerals. Lack of isomorphism, complexity of ions,

[1] For a description of this method see Papish, Brewer and Holt, *Jour. Amer. Chem. Soc.*, 49, 3028 (1927).

differences in solubility and volatility, may have caused the germanium to attach itself to other members of a given deposit. With this possibility in mind the search for germanium is being extended to a number of pegmatite and high temperature vein minerals, as well as to gangue materials. The spectrographic work on topaz, which is completed, proves conclusively that topaz in the massive as well as in the crystalline form contains germanium. Thirty-four specimens of topaz from twenty-seven different localities were examined and all were found to be germaniferous. Some topazes from Schneckenstein, Saxony and from Zinwald, Bohemia, were among those which contained minute traces of the rare element. Their spectrograms included only two of the most persistent germanium lines within the spectral range examined. The majority of topazes contained much more germanium, a fact substantiated by the larger number of spectral lines of this element. Notably among these were specimens from the following localities: Trumbull, Connecticut; Stoneham, Maine; Florissant, Colorado; Naegi Mino, Japan, and Silver Leaf Mine, Manitoba. Work is now in progress on the quantitative determination of germanium in topaz.

JACOB PAPISH

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HETEROTHALLISM IN THE RUSTS

THE cytological advances in the study of the rusts which revealed a pairing of nuclei with ultimate fusion, regarded as possible sexuality, definitely led to interest in the origin of the associated nuclei. The question whether the nuclei coming together in the fusion cell originated in separate cells of the same mycelium, or whether two separate mycelia might be involved, was a natural one. The possibility of the latter, heterothallism, has no doubt occurred to many workers and definite suggestions are not wanting (Dodge[1]; Arthur and Kern[2]). Cytological methods have not yielded any evidence. The most suggestive results have been brought forward by Craigie,[3] based on cultural studies.

Working with *Puccinia Helianthi,* Craigie[3] directed his attention toward producing infection from single basidiospores. Such infections lead to what he calls monosporidial pustules. He reports that in approximately 50 per cent. of the cases where monosporidial pustules are near enough together to coalesce aecia are promptly produced. Isolated monosporidial pustules develop pycnia, but usually do not develop aecia within two or three weeks, and then only in a minority of the infections. His results led him to the conclusion that the basidiospores are unisexual, producing unisexual mycelia, which interact when in contact, giving fusion cells in the spore-bed of the aecia. Later, working with *Puccinia graminis* cultures on the barberry as well as with *Puccinia Helianthi,* Craigie[4] reports that, in addition to contact and spontaneous development, there is a third manner in which monosporidial pustules may change from the haploid to diploid condition. This consists in the transfer of pycniospores from one monosporidial pustule to the pycnia of another monosporidial pustule. Flies are said to carry the pycniospores in the nectar. The facts seem to be clear that mixing the pycniospore-containing nectar does lead to early and abundant development of aecia. That this is due to germination of pycniospores, mycelial production and fusion to bring on the diploid condition has not been made clear. Craigie postulates that some of the monosporidial pustules have a + mycelium, others a − mycelium, each of course being haploid. He believes that when + and − mycelia come in contact the diploid condition is effected which results in prompt formation of the binucleate aecial structure.

There seems to be no doubt that the contact of two mycelia of monosporidial origin or the mixing of pycniospores has a positive and stimulating effect on the production of aecia, but no conclusive evidence of what happens has been brought forward. It is a well-known fact that when two cultures of ascomycetes are grown together on opposite sides of a petri dish more ascocarps may be produced along the line of contact than when either culture is grown alone. Many other instances have been cited showing that bacterial or fungous contaminations, as well as different colonies of the same fungus, may have a beneficial effect in stimulating the production of ascocarps. It is evident that the stimulation of the sexual reproductive process when two mycelia are growing in proximity is not necessarily a proof of heterothallism, although it may be admitted as an indication. The subject awaits further experimental investigation, accompanied by painstaking cytological observations, and may yield facts not only of biological interest but of practical importance.

FRANK D. KERN

THE PENNSYLVANIA STATE COLLEGE

[1] B. O. Dodge, "Uninucleated Aecidiospores in *Caeoma nitens,* and Associated Phenomena," *Jour. Agr. Res.,* 28: 1045–1058, 1924.

[2] J. C. Arthur and F. D. Kern, "Conversations with European Mycologists," SCIENCE, 63: 558–560, 1926.

[3] J. H. Craigie, "Experiments on Sex in Rust Fungi," *Nature,* 120: 116–117, 1927.

[4] J. H. Craigie, "Discovery of the Function of the Pycnia of the Rust Fungi," *Nature,* 120: 765–767, 1927.

THE OCCURRENCE OF OPISTOMUM PALLIDIUM O. SCHM. IN THE UNITED STATES

WARD and Whipple (18), in their "Fresh-water Biology," indicated that the genus *Opistomum* of the family *Dalyellidae* was not found in the United States. Von Graff (11) records new species of American *Dalyellia* but has not recorded *Opistomum*. Higley (18) did not find *Opistomum* among the rhabdocoeles of the Mississippi Valley. I have not been able to find any later reference to the *Dalyellidae* of the United States. It seems worth while, therefore, to record that *Opistomum* has been found in the vicinity of the University of Virginia. I have found four or five specimens in each of three collections made early in the spring of 1927. About the last of May the specimens were abundant in all collections made.

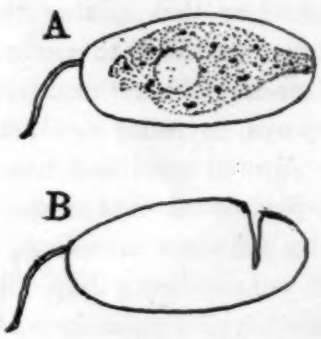

FIG. 1. *A*, camera lucida sketch of freshly laid egg. The egg was fixed to substratum by stalk shown at left end of shell; *B*, empty egg shell showing cleft through which young specimen had emerged. ×100.

All these specimens closely corresponded with Von Graff's (1882) description of the tribe *Opistomini*, a translation of which follows:

Dalyellidae with mouth and sexual opening in last third of body. The pharynx, arising from ventral surface of the intestine, is a long cylindrical tube with point directed backward. Two main branches of the excretory organ. A single median renal pore opening between mouth and genital pore. Vitellaria are not branched. Without bursa copulatrix. Independent uterus present. Rhabdites lacking. Chitinous structures of male copulatory organ furnished with numerous small needles of ductus ejaculatorum. One genus with character of tribe *Opistomum* (O. Schmidt). One certain species four and one half millimeters long from Europe; one uncertain species one and one half millimeters long from Australia.

The Australian species has eye-spots. My specimen lacked eye-spots. Moreover, it corresponded in all details with Von Graff's description of the species *Opistomum pallidium* (O. Schmidt). The specimens found in this locality represent this species.

In addition to recording this genus for the American fauna I am able to record that the specimens laid eggs in the laboratory aquarium during the latter part of April, 1927. The specimens would also lay eggs in depression slides whether isolated or in groups as great as five individuals to a depression. The egg was in each case deposited in the shallow marginal water of the depression slide. Each egg was fixed to the substratum by means of a slender curved stalk. Further, the eggs, thus deposited in depression slides, would develop. Data were kept for one of these eggs. April 23, 1927, two eggs were laid. Developmental changes were observed daily until, on April 28, a small *Opistomum* had left the egg through a subterminal cleft (Fig. 1-B). No attempt was made to rear the young individuals.

UNIVERSITY OF VIRGINIA M. E. CARTER

THE WORD CARIBOU

STUDIES relating to the historical origin of words may be quite as interesting and oftentimes more profitable than monographic reviews dealing in wearisome detail with the phyletic development of some organism concerning which the most of us know little and care less. Very recently in reading the journal of that intrepid explorer, Sir Alexander Mackenzie, describing a canoe voyage from Lake Athabasca to the Arctic Ocean down the great river now bearing his name[1] I was impressed by a paragraph and the possible significance it might have in throwing light upon the origin of the word "caribou." This is perfunctorily recorded in various dictionaries as being either of French Canadian[2] or of Indian[3] origin without further comment, although some editions of Webster state that it is derived from the Indian word meaning "pawer" without noting the specific word.

Mackenzie, while making the trip in 1787, writes in his journal as follows (p. 209): "We saw some rein-deer on one of the islands (Great Slave Lake) and our hunters killed five and two smaller ones . . . This island was accordingly named Isle de Carreboeuf." While it is not clear from the context as to the size a reindeer must attain before possessing a numerical value, the implication that "caribou" is derived from *carre* signifying four, and *boeuf* indicating bovine or ox, is fully apparent and seems to have escaped the attention of lexicographers. In the reindeer horns are possessed by both sexes and the number four may well refer to the fact that each horn has a large horizontal as well as perpendicular prong, so that there are four principal prongs. Some editions of Webster give "carribou" as a variant spelling.

[1] "Voyages from Montreal through the Countries of North America," London, 1801, Allerton edition.

[2] Webster's Dictionary—some editions; Standard Dictionary; Lettré, Dictionnaire Langue Français.

[3] Murray, New English Dictionary; Webster's Dictionary; Century Dictionary; Hatzfeld, Dictionnaire Langue Français.

It is of course not impossible that we are dealing with a word originating in a tribe of northern Indians and that Mackenzie made an error in suggesting its French origin. The Algonquin Indians as well as their relatives of the Great Slave and Athabasca regions, however, use the word "Atick," while the Esquimaux use the word "tuktu" for reindeer. Even should the word "caribou" appear in some of the Indian dialects, one would still be inclined to suspect its French paternity through contact with early traders.

Among the historical papers of the seventeenth or the latter part of the eighteenth centuries, particularly those relating to the fur trade, references should be found which will remove any existing doubts. In the meantime we may assume the following derivation: Caribou < carribou < Fr. *carre* < *quarre* < Lat. *quadri* = *quattour,* four + Fr. *boeuf* < Lat. *bos* < (*bov*) < Gk. *boûs,* ox, the four-horned ox.

L. B. WALTON

KENYON COLLEGE

"HABIT FORMATION"

THE note by Professor Wakeham[1] on this subject has such an important bearing on some current doctrines of psychologists that it may not be out of place to call attention to some implications involved. Professor Wakeham tells us that he "practised this passage, slowly and carefully, ten times daily, purposely putting in the wrong notes, for two weeks." The experiment very clearly demonstrates the fact that our organisms readily acquire certain habits of action which are followed without any thought on our part and that these habits dominate our conduct in very complicated cases. Most of us will be ready to admit that a very large proportion of our ordinary conduct is dominated in this manner and that this conduct is connected with some physical property of the organism.

But how does it happen that, in spite of these habits, Professor Wakeham was able to "put in the wrong notes"? The older psychologists would have said without hesitation that it is an illustration of conscious purpose. But "consciousness" and "purpose" are anathema to many modern psychologists. What words can be used in place of these to designate this phenomenon, which is so vitally important in our conduct—the ability we certainly have to do something contrary to our usual habit? It certainly seems difficult to account for it on the physical basis which we use to account for habits, for it is not habit at all.

Many modern psychologists deny the validity of introspection as a method of studying our mental conduct. How otherwise than by introspection does Professor Wakeham know that he tried the experiment he describes? Shall we deny the validity of the experiment because introspection was a part of it? In rejecting introspection are not psychologists rejecting one of their most important tools?

When Professor Wakeham tells us that he "put in wrong notes," the question immediately arises, why were they "wrong"? Were they wrong because they departed from the notes written by the author of the musical composition he was following or wrong because they were in violation of fundamental principles of musical harmony? To put it differently, were they wrong because of their departure from authority or because of a departure from the custom of musicians, or still again, because they were inherently objectionable to an untrained musical ear? But this would lead us far afield into questions of right and wrong in relation to conventions of society and in relation to the effect of conduct on the individual and on society, independently of conventions, if such a thing is ever possible.

W. A. NOYES

UNIVERSITY OF ILLINOIS

[1] G. Wakeham, SCIENCE, Aug. 10, p. 135.

QUOTATIONS

MUSEUMS AND GALLERIES

THE publication of an interim report by the Royal Commission on National Museums and Galleries will come upon most people with a little thrill of surprise. After sitting and taking evidence for twelve months, the commission has something so urgent to say that it can not wait till its final report is ready. The discontent which led to the appointment of the commission had long been brewing; but there is no need to go farther back than January of last year to find sufficient cause. In that month two important letters appeared in these columns. Lord Northbourne, writing as chairman of the Sudeley Committee, pointed out how greatly the British Museum and the National Gallery were hampered in their work for general education by lack of means, and Dr. Stanley Gardiner, writing for zoologists in general, complained that, for want of space, the Natural History Museum was losing golden opportunities of service to the health of man and the fertility of the earth. Dr. Gardiner's letter drew a sharp retort from Lord Cushendun, then Mr. Ronald McNeill, and financial secretary to the treasury, and others whose duty or hobby was national economy were not slow to protest against any suggestion of increased expenditure upon museums and galleries. The issue was joined. In July the commission was appointed, and among its terms of reference was this:

To consider in what way, if any, expenditure may be limited without crippling the educational and general usefulness of the institutions, and in particular, having regard to the financial condition of the country, whether it would be desirable to institute a more general system of admission fees.

Leaving out of account the convenient loophole in the vague word "crippling," there is still about that clause a strong suggestion of Balak, and in its interim report the commission plays Balaam, but a Balaam whose blessing is strongly in Balak's true interest.

Of the warmth of that blessing the report leaves no doubt. Our national collections can not be equaled, certainly can not be surpassed, by any collections in the world either in range or splendor. Their value in money, their value in national prestige, their value in education, is immense. And we have been treating these five talents very much as the man in the Parable treated his one talent. The tendency, says the report, has been too much to take the collections as a matter of course, without any adequate attempt to make the public aware of their outstanding quality. That such possessions, it continues, should be housed and exhibited with dignity (and, it might be added, in view of the state of things at the Natural History Museum, with facility of access) is of fundamental importance, and "in too many cases the cabinet is unworthy of its contents." We are, in fact, being guilty of one of the worst and stupidest kinds of waste—the neglect and misuse of our own property. We are letting our gates drop and our hedges go wild, our cigars get damp and the moth corrupt our curtains. To a very great extent private munificence has endowed us with these priceless possessions. We are not only failing to get the full benefit of these gifts; we are wasting the very money which, as taxpayers, we have contributed to the institutions that unworthily house them. And since "economy has already been pushed beyond the point of prudent administration," some of the defects are by now so glaring that the Royal Commission has been impelled to call immediate attention to the dangers and to formulate the least that can be done to remove them. The library of the British Museum must be enlarged. The Natural History Museum must have half a new building for entomology, half a new whale room and another extension. The National Portrait Gallery, which was full as soon as ever it was opened in 1896, must within two years have the first section of a long new wing. The conference room of the Science Museum must be completed. The Royal Scottish Museum needs certain alterations, and the National Library of Scotland, the famous old Advocates' Library, at present "chaotic and inadequate," must have its extension begun without delay.

All this is demanded in the names not only of art and of learning, but also of pounds, shillings and pence. Altogether the works would cost £779,000, spread over differing periods which range from fifteen years to two, the average annual expenditure being £52,000. That is "the irreducible minimum of works which ought to be set in hand immediately." It is also the most severely economic remedy which the commission could devise for arrears that have been accumulating for many years past, and especially since the war. It is less by £800,000 than the estimated cost of the larger schemes which were from time to time under consideration before the commission began its inquiry. That is an argument which will appeal to every one. The correspondence which was published in these columns last year was a clear reminder that there are still many people who resent every penny devoted to things of the mind; but even they can only evade the conclusions of the commission by denying the pecuniary value of the national collections, or by flying in the face of the common counsels of prudence in the management and preservation of property. The commercial value of works of art may be only measurable by national prestige and the number of visitors they bring to the country. That the commercial value of the collections and the research work at the Natural History Museum can be measured in simpler terms of human life and the products of the earth is known at any rate to the Empire Marketing Board, which lately gave the museum a large grant. And true instead of false economy is the main theme of the remarkable report which the commission has issued. The publication of the final report will be awaited with keen anticipation. It is sure to contain interesting and debatable matter, including, no doubt, some remarks upon that isolation and mutual independence of our institutions which has enabled and encouraged the treasury to discharge "with rigor" the task of denying them funds. The interim report, dealing only with matters that admit of no dispute, has a simpler purpose, of which it can hardly fail—the awakening of public opinion to the value of the nation's treasures and to the determination that parsimony and neglect shall no longer be allowed to depreciate them.—*The London Times.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE MICRO-ABRASO-TOME

WHILE acting as assistant to Dr. Carl O. Dunbar, of Yale University, in his recent research on the Fu-

sulinids, I became impressed with the great need for a more rapid and accurate method of making thin sections of fossils. The current method of grinding on a plate-glass lap is both slow and dangerous, as often facets are ground on the specimen so that when taken to thinness parts of it are lost by being ground away. Also it is extremely difficult to properly orientate the specimen. In addition the specimen is covered with sludge and has to be washed each time it is to be observed in the process of grinding to the desired plane or to thinness. It was with these difficulties in mind that I set to work to design a machine that would take the drudgery and uncertainness out of sectioning such forms as the Fusulinids, Nummulites, Bryozoa and similar fossils. The Micro-abraso-tome was the result.

This mechanism consists essentially of a motor-driven abrading wheel of very fine texture, above the periphery of which a specimen carrier is supported by a supporting table, hinged about an axis parallel to the axis of rotation of the wheel and adjustable with respect to it. Mounted on the supporting table is a microscope for observing the operation when taking the slide to thinness.

Fig. 1 shows the machine with the supporting table

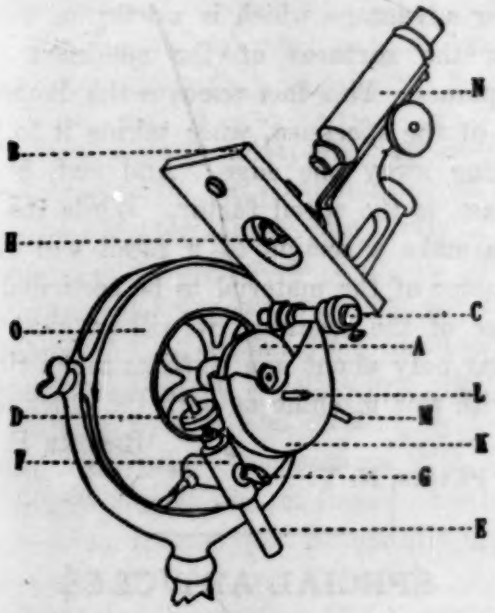

FIG. 1

raised, revealing the detail of the micrometer adjusting screw, abrading wheel and hinge axis. On the base rests the specimen carrier, with a specimen held in the jaws of the clamp. Fig. 2 shows the supporting table lowered to cutting position on the micrometer screw, the abrading wheel showing through the opening of the table. The specimen carrier has been removed. Fig. 3 shows the details of the specimen holder.

The abrading wheel (A) is motor driven and turns counter-clockwise. It is on the periphery of this wheel that the cutting is done. The supporting table (B) is hinged about the axis (C), which is parallel

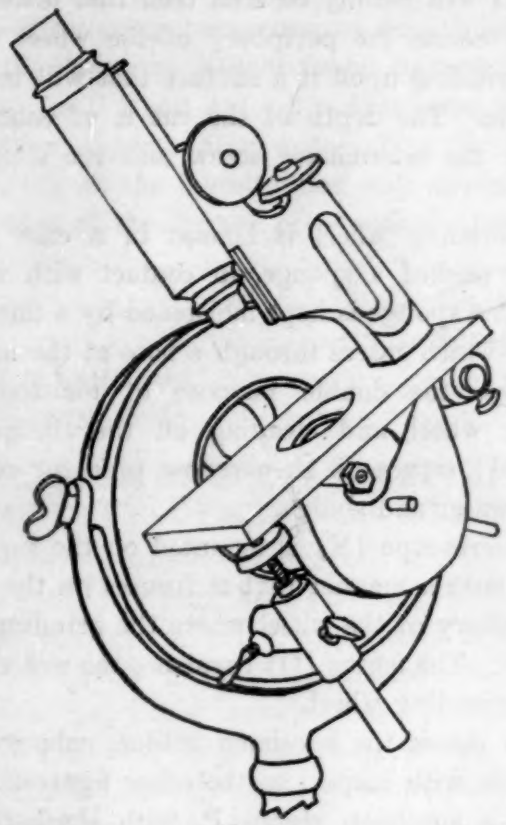

FIG. 2

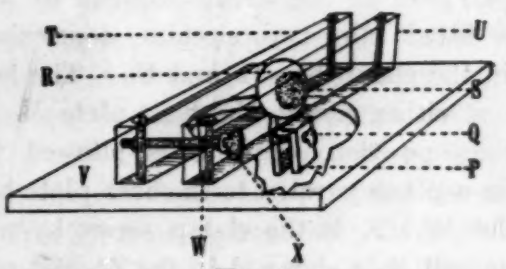

FIG. 3

to the axis of rotation of the wheel. This table is supported at the other end by the micrometer screw (D), which is inserted in the end of the rod (E). This rod has a sliding adjustment through the sleeve (F) and is clamped by the screw (G). This whole adjusting mechanism which supports the movable end of the table is for the purpose of adjusting the height of the table above the periphery of the wheel. In the center of this supporting table and directly above the periphery of the wheel is a round opening about two inches in diameter. It is in this opening that the specimen (H), held in the clamp of the specimen carrier, which in turn is supported by the plane upper surface of the table, is suspended. If the specimen has been ground to the desired plane and cemented on a slide, it is the slide that rests on the surface of the supporting table while the specimen projects down through the hole in the table as before. In either case the specimen is free to move in any direction, but only in one plane, namely, parallel

to the top of the supporting table, which is at all times parallel to the axis of rotation of the abrading wheel. It will readily be seen then that drawing the specimen across the periphery of the wheel will result in grinding upon it a surface that will be a perfect plane. The depth of the cut is of course governed by the micrometer screw and the sliding rod (E).

The abrading wheel is housed in a case (K) in which is packed a sponge, in contact with which it runs. This sponge is kept moistened by a fine stream of water which enters through a hose at the inlet (L) and serves the double purpose of moistening the abrading wheel and cleaning off the sludge. The outlet (M) serves as an overflow pipe for removing surplus water and sludge.

The microscope (N) is mounted on the supporting table in such a manner that it focuses on the spot on the periphery of the wheel where the grinding is taking place. The motor (O) furnishes the motive power for the abrading wheel.

Fig. 3 shows the specimen holder, enlarged about four times with respect to the other figures. It consists of a specimen clamp P, with checkered jaws which are closed upon the specimen by set screw Q. The upper part of the clamp consists of a ball R which is fitted into two circular depressions (S) ground in the clamp bars T and U. The latter are fastened at either end to the base plate V, T being fixed in its position, while U is allowed to move slightly in a plane parallel to the base plate by means of the slot W. X is the clamp screw by means of which the ball R is clamped in the desired position.

In operation the process is simple. The specimen is placed in the jaws of the clamp of the specimen carrier, orientated and made fast. The specimen carrier is then placed with its plane lower surface upon the plane upper surface of the supporting table and the clamp, with the specimen in it, projecting down through the opening in the table. The table is then lowered by means of the sliding rod until the specimen comes in contact with the abrading wheel. It is then planed off and the lowering process continued by means of the micrometer screw until the desired plane is reached. If, however, after making a cut or two it is found that the preliminary orientation was not correct, the clamp is shifted in its universal joint until the desired position is reached and then made fast again, with respect to the specimen carrier. The specimen carrier is again placed on the supporting table and the process of grinding continued.

When the desired plane has been reached, the specimen is taken out of the clamp and cemented to a slide with Canada balsam, that has been cooked until it will shatter when crushed under a testing tool. The glass slide then assumes the rôle of specimen carrier, which it replaces at this stage, and the specimen is ground down from the other side in the same manner as before, except that now the process may be observed through the microscope as the grinding progresses. Thus one is enabled to observe the changing appearance of the slide as it becomes thinner, and to stop the process when the desired amount of detail is observed.

As will be apparent, one of the greatest advantages of this machine is the fact that it affords perfect control at all times. Once the specimen is orientated and clamped in the specimen carrier, this orientation is assured throughout the process, regardless of the number of times the specimen carrier is removed from the table for observation or other purposes. Through the micrometer screw the depth of each cut may be minutely regulated, thus enabling the operator to stop at any desired plane. As noted above, the microscope reveals the changing character of the specimen as it is ground thinner and thus enables the operator to stop at the most advantageous thickness.

Another advantage which is worthy of note is the fact that the surfaces of the specimen slice are parallel planes. This fact removes the danger of losing part of the specimen, when taking it to thinness, by grinding away one edge. And last, but by no means least, is the speed factor. While the time required to make a section of a fossil will vary with the character of the material to be sectioned and the experience of the operator, it will in most cases be found that only about one sixth as much time is required with this machine as with the older methods.

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SPECIAL ARTICLES

SERIES IN THE ARC SPECTRUM OF CHLORINE[1]

AT various times during the past five or six years wave-length measurements of the spectrum of chlorine have been made at the Bureau of Standards. This work has corroborated to a large extent previous investigations by others describing limited portions of the spectrum, and has extended our knowledge of the spectrum into the hitherto unexplored regions in the red and infra-red. These new wave-lengths, characteristic of the arc and spark spectra as emitted

[1] Publication approved by the Director of the Bureau of Standards, of the U. S. Department of Commerce.

by Cl-filled Geissler tubes, extend from 2300A in the ultra-violet to 9900A in the infra-red.

With the aid of these new lines and those in the extreme ultra-violet, published by Turner,[2] we have succeeded in working out the structure of the arc spectrum of chlorine, Cl I. In its unexcited state the outer electron configuration of the chlorine atom is s^2p^5 from which, according to Hund's theory,[3] we may expect the lowest term of the spectrum to be ^2P. This term and others arising from the various electron configurations assumed by the excited atom are based on the term ^3P of Cl II, which was established by Bowen.[4] In the following table are listed the theoretical terms to be expected, those already found in this investigation being printed in heavy type. Terms based on ^1D and ^1S of Cl II will produce only faint lines and are here omitted.

Electron Configuration	Doublet System Terms	Quartet System Terms
s^2p^5	**P**	
$s^2p^4 \cdot 3d$	**F D P**	**F D P**
$s^2p^4 \cdot 4s$	**P**	**P**
$s^2p^4 \cdot 4p$	**D P S**	**D P S**
$s^2p^4 \cdot 4d$	**F D P**	**F D P**
$s^2p^4 \cdot 5s$	**P**	**P**
$s^2p^4 \cdot 5p$	**D P S**	**D P S**

Turner's lines, already interpreted by Bowen[5] and by Laporte,[6] represent the combinations of the odd lowest ^2P term with the higher even terms ^2P and ^4P coming from the configuration $s^2p^4 \cdot 4s$. The new lines in the red and infra-red represent the combinations of ^2P and ^4P ($s^2p^4 \cdot 4s$) with the doublet and quartet, S, P, and D terms arising from $s^2p^4 \cdot 4p$. A still higher set of doublet and quartet, S, P, and D terms arising from $s^2p^4 \cdot 5p$ combines with the even terms ^2P and ^4P to give the arc lines in the blue and violet described by Asagoe[7] and beautifully illustrated in the map given by Eder and Valenta.[8]

It is thus seen that in structure Cl I closely parallels A II, recently worked out by De Bruin.[9] The ^2S and ^2P terms which arise when the activated electron is raised to the $4p$, $5p$, . . . orbits, form Rydberg series from which the value of the lowest term may be derived. This value turns out to be 106000 which agrees with the value 105000 found by interpolation from those for S I and A I. The ionization potential of the neutral chlorine atom is therefore 13.1 volts.

The details of the investigation will appear in an early number of the *Bureau of Standards Journal of Research*.

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WASHINGTON, D. C.

[2] Turner, *Physical Review*, 27: 402, 1926.

[3] Hund, "Linienspektren und Periodisches System der Elemente," Berlin, 1927.

[4] Bowen, *Physical Review*, 31: 34, 1928.

[5] Bowen, *Physical Review*, 31: 498, 1928.

[6] Laporte, *Nature*, 121: 1021, 1928.

[7] Asagoe, *Mem. College of Science*, Kyoto, A 10: 15, 1926.

[8] Eder and Valenta, "Beiträge zur Photochemie und Spectralanalyse," Vienna, 1904.

[9] De Bruin, *Kon. Akad. Wet. Amsterdam*, 37: 553, 1928. *Zeitschrift für Physik*, 48: 62, 1928; and 50: 1928.

THE RELATION OF CERTAIN BACTERIA TO THE DEVELOPMENT OF ROOTS[1]

AN excessive localized development of small fibrous or fleshy roots has long been observed to occur on varying percentages of young apple trees in the nursery. Considerable doubt has attached both to the cause of this "hairy-root" condition and its effect upon the tree. The first important contribution to the knowledge of the etiology of this trouble was made by Smith and his coworkers[2] in their extensive researches on crowngall. They isolated from "hairy-root" malformations on young apple plants bacteria which they state "culturally and morphologically differ, if at all, only slightly from the crowngall organism." They report that five of eight young apple trees inoculated through punctures with these bacteria developed hairy-root symptoms, one developed galls and the other two remained free from malformations. Of four controls, none developed hairyroot, though one developed several galls. They do not report reisolation of the organism from hairyroot malformations on the inoculated plants or precautions to preclude the possibility that organisms from the soil may have played a part in inducing these hairyroot developments. However, they isolated from the inoculated tree which developed only galls an organism which, when plated, "looked typical for what was inserted." They state that this organism, when inoculated into healthy sugar beet, "produced both galls and hairy roots, indicating

[1] Published with the approval of the director of the Wisconsin Agricultural Experiment Station. These studies were begun as a part of the Wisconsin program in the crowngall project supported cooperatively by the Crop Protection Institute, the Iowa State College of Agriculture and Mechanic Arts and the University of Wisconsin, and have been continued in cooperation with the United States Department of Agriculture.

[2] E. F. Smith, Nellie A. Brown and C. O. Townsend, "Crowngall of Plants: its Cause and Remedy," U. S. Dept. Agr., Bur. Plant Indus. Bul. 213: 200, 1911.

that crown-gall and hairy-root are only two forms of the same disease." They worked more extensively with hairyroot and crowngall on other plants than apple. Among the isolations of bacteria which they studied, they recognized differences in pathogenicity and certain other characters, but preferred, on the basis of the evidence then at their command, to leave the species *Bacterium tumefaciens* Smith and Town. undivided.

Following the work just cited, the conception that hairyroot is caused by *Bact. tumefaciens* and is a phase of the crowngall disease became widely accepted.[3] The results of the present cooperative research, while in substantial accord with the experimental data published by Smith and his coworkers, furnish additional evidence which suggests that the etiology of the hairyroot condition is more complex than was earlier apparent.

Muncie[4] differentiated two types of abnormal root development on apple which he called "fibrous hairyroot" and "woolly knot." The former occurred quite commonly on apple seedlings, including lots grown from seeds which had been dipped for five minutes in mercuric chloride, 1–1,000, and planted in steamed soil. He concluded that this type is "probably noninfectious," and that the "'woolly knot' form is a manifestation of crowngall infection."

In previously reported studies of crowngall, callus and wound overgrowth on the crown and roots of grafted apple nursery stock, two of us[5] found that typical, highly pathogenic strains of *Bact. tumefaciens* were consistently isolated from galls which had been induced by inoculations with pure cultures of this organism and from galls of like appearance found on commercial nursery stock. From a large majority of the naturally occurring malformations that were studied, however, the technique used failed to isolate the typical, highly pathogenic crowngall organism. From many of these malformations which failed to yield the virulent crowngall bacteria, were isolated organisms which were similar to *Bact. tumefaciens* in certain routine diagnostic characters, but which failed to induce positive evidences of infection when inoculated through punctures into stems of tomato, tobacco, Pelargonium or apple. Establishment of the identity of these organisms and an interpretation of their relations to the plants with which they are associated was left to await further investigation. A brief report of progress on studies of these problems follows.

Many strains of bacteria which closely resemble *Bact. tumefaciens* on certain agar media, but which failed to cause infection when inoculated into tomato stems, were isolated from certain malformations on underground parts of grafted apple nursery trees. In numerous series of experiments they were inoculated by punctures into underground parts of one- or two-year-old grafted apple trees of the Wealthy variety. At the end of the growing season no typical crowngall or hairyroot was observed. However, in certain cases small enlargements or sparse root developments occurred at the places of inoculation. In later experiments, conducted in the spring and summer of 1927, similar inoculations were made into underground parts of the current year's shoots from the scions of newly set grafts as they developed in the nursery row. After a minimal incubation period of approximately six weeks, fleshy roots were found at the places of inoculation. They occurred singly or in groups and usually arose from slight enlargements. No root development or other malformation occurred about the punctures on control plants. In repetitions of this experiment in the field and in the greenhouse fifteen strains (isolations from fifteen sources) of bacteria of this type have been inoculated into young shoots of apple. Every strain stimulated root development. Control punctures gave uniformly negative results. The enlargements which occurred at the bases of these excessive root developments yielded cultures which, in each case, appeared on agar plates to be typical of the culture from which the inoculation had been made. Reinoculations have been made with each of the strains reisolated. As yet, results are available from but three of these. In each case the typical root stimulation occurred, while controls developed no malformations. In connection with these experiments similar inoculations were made from cultures of typical highly pathogenic *Bact. tumefaciens*. In every case typical crowngall developed. In no instance was any evidence of root stimulation observed. Controls developed no malformations.

Five of these root-stimulating cultures which were isolated from apple have been inoculated by punctures into underground parts of young shoots of honeysuckle (*Lonicera morrowii* Gray) and rose (*Rosa setigera* Michx.). On both honeysuckle and rose, each strain stimulated root development in a striking manner. In all cases control punctures gave negative results.

All the experiments on honeysuckle and rose and a portion of those on apple were performed in the greenhouse in steamed soil and under conditions de-

[3] A more complete review of literature will appear in a later paper.

[4] J. H. Muncie, "A Study of Crowngall Caused by *Pseudomonas tumefaciens* on Rosaceous Hosts," *Ia. State Coll. Jour. Sci.* 1: 57–110, 1926.

[5] A. J. Riker and G. W. Keitt, "Studies of Crowngall and Wound Overgrowth on Apple Nursery Stock," *Phytopath.* 16: 765–808, 1926.

gned to preclude chance intervention of *Bact. tume-ciens* or any similar organism.[6]

Bacteriological studies are being made of a series f these root-stimulating organisms in comparison ith various soil organisms and *Bact. tumefaciens* iso-ted from typical crowngalls on apple. Although is work is incomplete, the data available have al-ady established certain important differences be-een the root-stimulating cultures and the typical, all-inducing *Bact. tumefaciens* of Smith and Town-nd. These differences relate both to physiology and athogenicity and are probably of specific rank.

The results thus far obtained give promise of eluci-ating at least one phase of the hairyroot question. t the same time they seem to open problems of much otential scientific and practical interest. What is the ature of the relationship of these root-stimulating rganisms to the plants with which they are asso-iated? Is it harmful or beneficial to the plant? If armful, may these organisms be controlled economi-ally; if beneficial, may they be adapted to use in lant culture to facilitate root development?

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THE MECHANISM OF PELLET FORMATION IN THE GREAT HORNED OWL (BUBO VIRGINIANUS)[1]

It is well known that many birds, at varying inter-vals after feeding, regurgitate pellets composed of bones, fur, feathers and other indigestible materials, compactly arranged and free from digestible con-stituents as shown by the absence of any evidence of decomposition even after several days. The de-tailed report by B. P. Reed[2] on the formation of these pellets in the great horned owl suggested the use of this species as experimental subjects in an attempt to gain some information on the mechanism involved in delaying the passage of certain food materials through the stomach as occurring in higher forms. Of all the common birds displaying this phenomenon the owl forms the largest pellets and so seemed best adapted to the purpose.

Seven nestlings were secured at about the age of four weeks and raised in captivity so that they might become accustomed to handling. All but one became fairly tractable when properly handled. None was submitted to any experimental procedure until about six months old, at which time they had attained adult development.

One method of study was by fluoroscopic examination after ingestion of barium paste or of food mixed with paste. In the latter procedure freshly killed rats or guinea-pigs were cut into pieces and these rolled in thick paste, or raw liver was similarly treated; in other experiments finely minced meat, containing bones, hair or feathers, was mixed with barium paste and enclosed in small gauze bags and a definite number of these swallowed by the bird. It was then possible to count and locate these under the fluoroscope. These bags were invariably regurgitated as pellets entirely freed from digestible material in from twelve to twenty hours, the normal range of time involved in this process.

Another procedure involved aspiration of gastric juice at various stages of digestion. Usually not more than one or two cubic centimeters of fluid could be obtained, indicating that gastric secretion is not profuse at any time in this species. This material was tested for free and total acidity and peptic activity. All samples were highly viscid, dark in color, malodorous but never putrid.

Freshly regurgitated pellets were extracted with a measured quantity of water, squeezed dry and the extract filtered and tested as above, acidity being calculated for the original moisture content. These contained from two to three cubic centimeters of juice.

Two birds were killed at different stages of digestion of a meal consisting of the chopped body of a freshly killed rat, and the stomach contents examined both grossly and chemically.

Two trials at the preparation of gastric fistulae failed, but a third was successful, the bird continuing in a healthy state for several months and was finally killed for examination. But at no time was it possible to obtain enough gastric juice from the fistula for examination during digestion. Only a few drops were ever observed to escape from the opening at any time. This is a further indication that gastric secretion is not profuse in this species.

Post-mortem examination showed the pyloric opening of the stomach to be only about 1 mm in diameter, and in the normal position under the fluoroscope it was always found to lie on a level with the opening of the esophagus, so that practically the entire content

[6] On May 3, 1928, when the present paper was being repared for publication, the writers were pleased to learn hrough correspondence that Miss Nellie A. Brown, of the Bureau of Plant Industry of the United States Depart-ent of Agriculture, in unpublished work, has induced he development of hairyroot on Paris-daisy plants which ere inoculated with bacteria isolated from hairyroot on pple.

[1] From the Hull Physiological Laboratories, University f Chicago, and the Department of Physiology, Baylor edical School.

[2] B. P. Reed, 1925, *The Auk*, xlii, 14.

of the stomach, even when greatly distended, lay below the level of the pylorus. Under the fluoroscope movements of the pylorus were never observed. Apparently a thin stream of liquid flowed through without obstruction. The pyloric opening appeared to be about the same diameter as found post-mortem. These facts indicate that there is a mechanical bar to passage of anything but finely divided material from the stomach to the intestine.

Incidentally, it was found that when the thorax was opened under an anesthetic the bird continued to breathe with no difficulty by reason of the fact that the lungs were so attached to the ribs that costal movements distended them without any involvement of pressure changes. Birds in this condition were observed to continue adequate respiration for as long as thirty minutes.

Gastric Motility

Two of the subjects were especially tractable and when blindfolded could be observed repeatedly for brief periods over several hours or an entire day on the fluoroscope. It is believed that the gastric motility observed under these conditions was normal in every way and not inhibited, since pellet regurgitation was not delayed in any case.

At no stage of digestion was any extensive motility observed. By sketching on the screen the outlines of the stomach at successive observations it was possible to compare the position and shape at different stages. As emptying progressed there was always reduction in diameter in every direction. Such movements as were observed consisted of very gentle peristaltic waves beginning near the cardia and progressing continuously to the region of the pylorus. This is in keeping with the anatomical structure of the stomach. The musculature is very thin and hence not adapted to any great degree of motility.

Apparently, a mechanism similar to vomiting in higher forms is involved in regurgitation, since the subjects show evidence of nausea for fifteen or twenty minutes before the mass is discharged. The feeble musculature of the stomach precludes the involvement of any great force. However, the esophagus is very large and distensible, so that there is no apparent bar to easy discharge. On a few occasions when it was observed that regurgitation was imminent, very gentle pressure with the hand on the abdominal wall was sufficient to cause immediate expulsion of the pellet. In spite of feeble gastric motility during digestion, it is apparent that the musculature is sufficiently active to discharge indigestible masses. No information is available at present as to the nature of the reflex mechanism involved in the process.

Acidity

No free acidity was present in gastric contents at any stage of digestion nor in the extracts of pellets. Twenty-eight samples of gastric contents and six pellets were tested, using methyl orange as an indicator. Total acidity in one sample taken five hours after eating was found to be 0.155 per cent.; in another sample taken two and one half hours after a meal total acidity was 0.437 per cent.; four hours after, 0.282 per cent.; in case of the entire stomach contents secured by killing the bird four hours after feeding, total acidity was 0.063 per cent.; a pellet regurgitated twenty hours after feeding was extracted and total acidity was found to be 0.2 per cent. while in another regurgitated by the same bird after a comparable period total acidity of the extract was found to be only 0.07 per cent. These figures are typical of the many determinations. The absence of free acidity possibly accounts for the fact that bones in the pellet masses showed no evidence of corrosion. The ends were sometimes crushed and broken, but this apparently occurred before swallowing as the birds are accustomed to crush food masses in the beak. The broken edges were always sharp and clean and when examined under a low-power microscope showed no evidence of corrosive action. Furthermore, pigment in hair and feathers appeared to be undisturbed.

Peptic activity was found to be generally about three times as potent as that of dog gastric juice at comparable stages of digestion.

Observations made by killing during digestion and examining the gastric contents showed that there was no mixing of materials after swallowing, as small masses of different colored hair retained their original relative positions. The outside of the pellets consisted of hair and bones cleanly freed from digestible materials, while there was progressively less digestion in evidence toward the center of the mass.

These observations indicate that the mechanism of pellet formation involves three general factors: first, the mechanical factor of high placement and small size of the pyloric opening; second, feeble gastric motility which would preclude stirring up or freeing of hair or feathers enmeshed in the whole mass; third, potent peptic activity which would readily digest all other material free from hair, feathers and bones, and liquefy it so that pyloric passage would be facilitated.

So far as present evidence indicates there is no relation between pellet formation and the selective passage of food materials from the stomach as occurring in higher forms.

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